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CORALS AND CORAL ARCHITECTURE.

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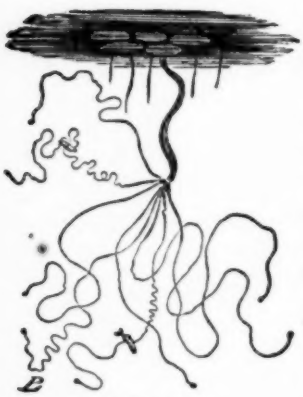
THERE are forests and gardens in the depths of the sea. Stately, tree-like structures inextricably branched, and a multitudinous shrubbery, delicate in form, and crowned with brilliant perennial blossoms, constitute a world of life and beauty in the obscurities of the ocean, where the eye of man but rarely penetrates.

But what kind of life is that which produces such wonderful growths? The similarity of the appearances to a garden was too striking not to suggest an answer, for what but vegetal forces can produce growing branches covered with flowers? And so Theophrastus, the old Greek botanist, described these sea-structures as of vegetal origin, and this opinion prevailed for 2,000 years. It began at length to be suspected that the old notion was wrong, and in 1751 Peyssonnel sent to the Royal Society an elaborate memoir, in which he maintained that these ocean-forests are really formed by little animals. This, as a matter of course, was indignantly disputed, and was pronounced by the great Réaumur too absurd to be discussed. To ascribe to "poor, little, helpless, jelly-like animals" the skill and power necessary to build such stately and beautiful structures, looked like a wanton appeal to human credulity, and the point was hence warmly controverted. Linnæus, however, proposed a compromise. He would admit the animal, but would not deny the vegetable. He therefore assumed that these little toilers of the sea were of an intermediate nature, and named them *zoophytes*, animal-plants. But the coral-polype is now known to be as truly an animal as a cat or a dog. The apparent flower is a little sac-like creature, and the wreath of colored petals its arms or tentacles. These are arranged around its circular mouth to seize and draw in the food upon which it lives and grows, while the structures which it produces are not perishable wood but enduring stone.

But, lowly organized and apparently insignificant as these animals are, the part they play in the operations of Nature is in the highest degree imposing. Not only do they produce these exquisite arborescent forms, but they build gigantic structures with caverns, grottoes, and mighty arch-work, and raise rocky walls, which rival in extent and massive grandeur the noblest mountain scenery upon the land. Though these constructions proceed but slowly, yet in numbers that are inconceivable, and through ages that are incalculable these tiny beings have been engaged in the work of rock-manufacture, until they now rank with earthquakes, the rising and sinking of continents, and other stupendous agencies by which the crust of the globe has been shaped. Multitudes of islands, hundreds and thousands of feet above the surface of the sea, and multitudes of others sunk thousands of feet below it; stony reefs, along which the navigator sails hundreds of miles; the sheet of rock through which Niagara is slowly cutting its way, and extensive beds of limestone scattered over the continents—all have a common origin—all have been extracted from sea-water and secreted by animals low in structure, and chiefly by these jelly-form polypes, many kinds of which are so minute as to be hardly visible to the naked eye. Living, working, multiplying, and dying like ourselves, building blindly but grandly in the final result, perhaps here also not unlike ourselves, these humble creatures illustrate the method of Nature, and their works and ways are of inexhaustible interest. Their instructive story has just been told by Mr. Dana, with the fascination of romance and the fidelity of science, in his charming book on "Corals and Coral Islands." In the present brief presentation of some of the facts of the subject we shall chiefly follow Prof. Dana, and we are indebted to the courtesy of his publishers for the accompanying illustrations from his work.

FIG. 1.



Fresh-water Hydra.

The animal kingdom is divided into several sub-kingdoms, one of which comprises numerous species of animals termed *Radiates*, because their parts are arranged radially round a centre. One division of the radiates is known as *polypes*, and they have the faculty of secreting a stony frame or skeleton, which is termed *coral*. The polypes are the most important coral-making animals, but this substance is produced also by other radiates, by some of the lowest tribes of mollusks, and a kind of coral is made by lime-secreting sea-weeds.

There is a group of radiates termed *Hydroids*. One of these, the fresh-water hydra, is represented in Fig. 1, as it is often seen attached to the under surface of a floating leaf. Prof. Dana says: "It is

seldom over half an inch long; it has the form of a polype, with long, slender tentacles, but no special organs except a mouth and tubular stomach. Like the fabled hydra, if its head be cut off, another will grow out, and any fragment will, in the course of a short time, become a perfect hydra, supplying head or tail, or whatever is wanting, and hence the name given to the genus by Linnæus."

FIG. 2.

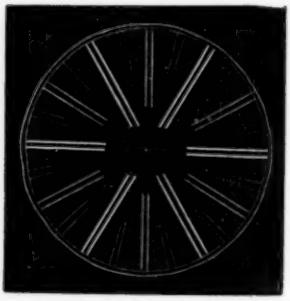
Plumularia; a Coral Sprig made by Hydroids, not more than the fiftieth of an inch long.

Some of the hydroids are coral-makers. Fig. 2 represents the kind of work done by one of them. It certainly looks like a plant, and, in allusion to its delicate plumes, it is called *Plumularia.* Along

the branches are minute cells (indicated by the fine dots in the wood-cut), each of which was the seat of one of the little hydra-like animals (in this case not more than the fourth of a line long), and usually with short tentacles spread out star-like.

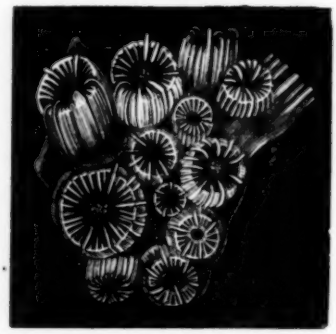
"We will now pass to the true polypes. These may be divided into those which secrete coral and those which do not. The latter

FIG. 3.



A n Horizontal Section of a Polype, showing the Internal Arrangement of the Folds and Compartments.

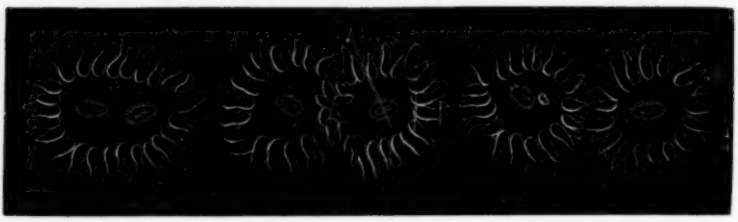
FIG. 4.



Coral from the West Indies, showing the Structure of the Cells.

have soft, leathery bodies, and live attached to stones and other substances upon the sea-bottom, by a basal, sucker-like disk. They have the power of locomotion by contraction and expansion of the muscles of the disk. But the coral-making polypes are fixed to the stone which they create, and which is part of themselves. The polype is the living part of the coral, the gelatinous mass which

FIG. 5.



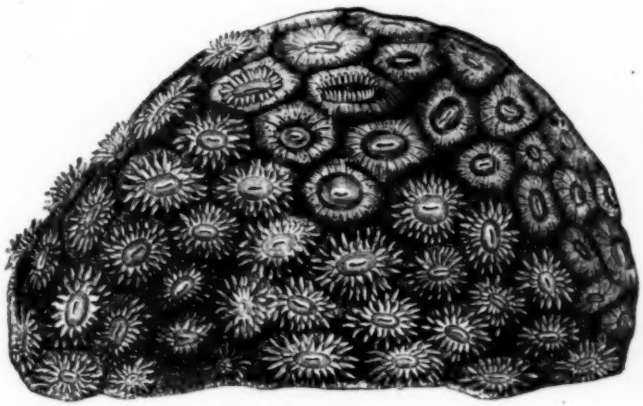
Multiplication of Polypes by Spontaneous Fission.

fills the radiating cells upon the coralline surface. It consists of a sac or stomach, and an enveloping membrane. An opening from the stomach outward is the animal's mouth. This is surrounded by tentacles, which by their motion aid in bringing to it currents of water in which floats its food, and of the solid matters of which it constructs its calcareous skeleton." In the polype, the stomach or digestive sac, with its appendages, constitutes the whole animal. Into the stomach

the sea-water passes freely, and carries the digested food through the internal cavities. There is no other circulation of fluids.

Fleshy folds or partitions extend from the upper to the lower end of the animal, and give to the polype the appearance of a little balloon of tissue-paper crumpled up. These radial folds in the animal's structure are illustrated in Fig. 3, page 260, which is an ideal sectional view of one of this class of animals. The radiating partitions or folds are seen to be arranged in pairs. In the coral-secreting polypes these pairs are six or five, or multiples of six or five. The space between each of these partitions opens into the tubular tentacle at the top of the animal. The tentacles of the polypes moving freely and with con-

FIG. 6.



Coral from the Feejees, called *Astræa*, from the Star-shaped Cells.

siderable muscular strength, seem sufficient to supply the animal's wants, but it has a formidable armature in the stinging barbs which cover its tentacles, mouth, and stomach, and which produce torpor and death in any small animal brought in contact with them. These are called *lasso-cells*. The cells in which the lasso or barbs are located measure from $\frac{1}{300}$ of an inch to $\frac{1}{5000}$ of an inch in length. From these the lasso is projected, inflicting, in some species, upon even a human hand, painful and serious injury. Owing to this peculiarity of certain jelly-fishes, they have been appropriately named *sea-nettles*.

Between the fleshy partitions of the polype's body are thin, stony plates. These, with the other hard portions, make up the coral skeleton, and are wholly secreted by the polype. Fig. 4, page 260, represents a group of polypes (*Phyllangia Americana*) from the West Indies, and illustrates well the radial structure of the cells.

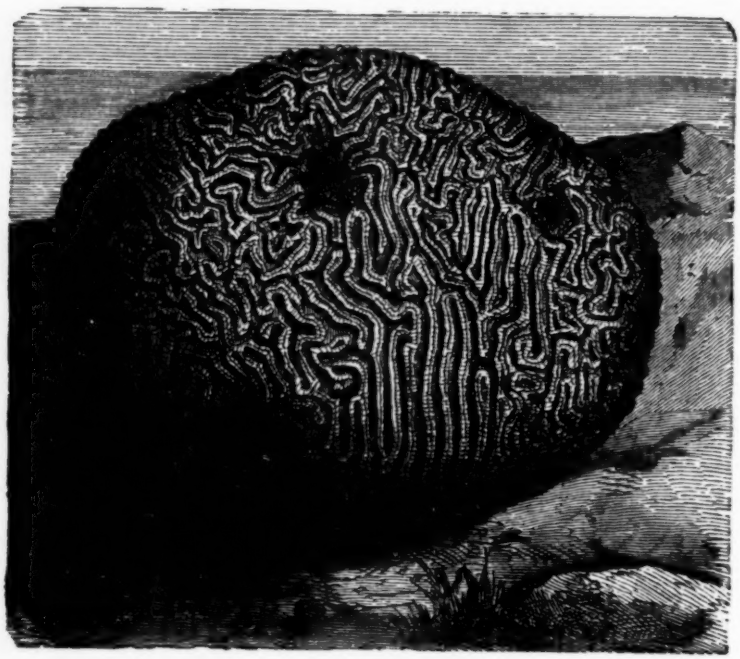
The secretions occur around and underneath the polype, never in its interior, which would interfere with its functions. It constructs its skeleton by secretion, as an oyster does its shell, or as the tissues of a

vertebrate animal do its bones; an act wholly involuntary in both cases.

Therefore, when we speak of the labors or architecture of the coral animal, we do not imply outside mechanical work as the bee in constructing its comb, but simply the operation of a vital function. "This process of secretion," says Prof. Dana, "is one of the first and most common of those that belong to living tissues. It belongs eminently to the lowest kinds of life. These are the best stone-makers, for in their simplicity of structure they may be almost all stone, and still carry on the processes of nutrition and growth."

The young polype in the reef-building species arises by a process of budding from the parent animal. It was from this curious operation that early observers strengthened their argument in favor of the vegetable nature of corals. "The bud," says Dana, "commences as a slight

FIG. 7.



Brain-coral.

prominence on the side of the parent. The prominence enlarges, a mouth opens, a circle of tentacles grows out around it, and increase continues until the young finally equals the parent in size. Since in these species the young do not separate from the parent, this budding produces a compound group."

From this it is obvious that, while the polypes exist as individuals,

they are nevertheless connected by intervening tissues which form a thin sheet of animal matter covering the surface of the coral, and through which fluids circulate. This sheet of animal matter unites the polypes, but does not destroy their individuality. The budding process

Fig. 8.

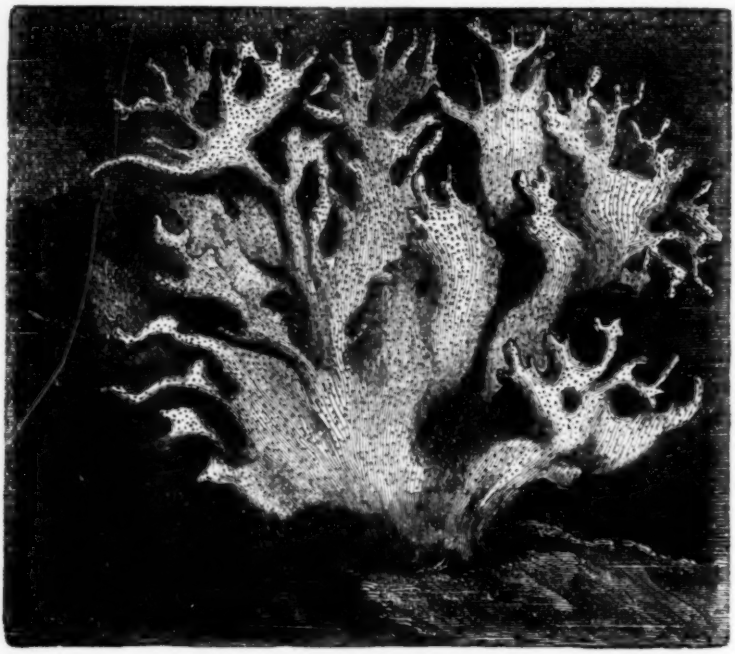
Porites from the Feejees; Cells exceedingly small.

takes place in some species by a spontaneous division of the parent polype. So that in the same cell a new polype forms side by side with the old one (Fig. 5, page 260), and begins an individual life, but the results are essentially the same.

The reef-building corals comprise all those with a stony skeleton, yet the great work is carried on mainly by a few of the principal groups. Of these the following are the most conspicuous and familiar:

The *Astræas*, so called from their star-shaped cells (Fig. 6, page 261). They grow in huge hemispherical masses, often twenty feet or more in diameter. The *brain-coral*, covered with meandering furrows and ridges resembling cerebral convolutions (Fig. 7, page 262). The masses are large, and are shaped like the astræa. The *Porites*, often branched,

FIG. 9.

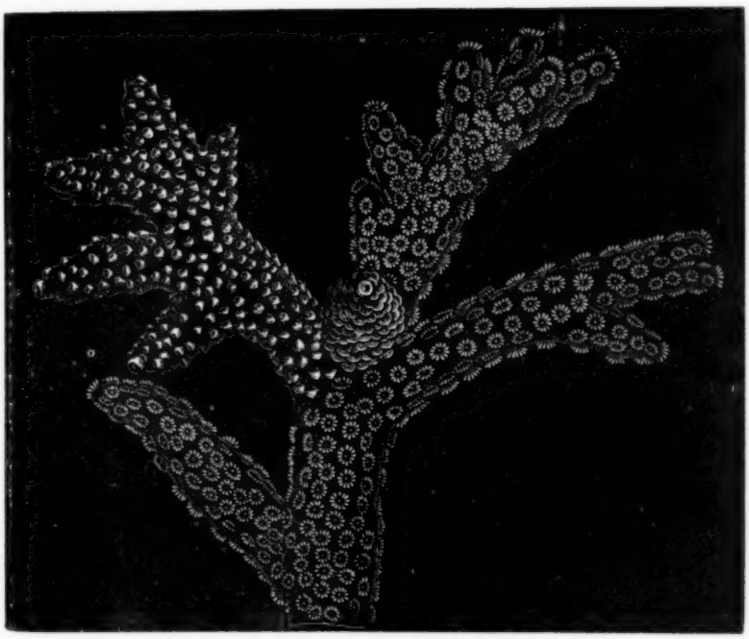


Millipores; Coral secreted by Jelly-fish (Acalephs).

sometimes massive and covered with exceedingly minute cells, are represented in Fig. 8, page 263. Other species are branching or lamellar, as the *Millipores* (Fig. 9), which contribute largely to the material of the West-India reefs. The animal, however, in this case, is not a true polype, but belongs to the group of *acalephs*, or jelly-fishes. Then there are the beautifully branched, tree-like *Madrepores* (Fig. 10, page 265). Fig. 11, page 266, represents one of the most beautiful of the corals produced by the *alcyonoid* polypes. Almost all of these are flexible, and sway with the moving waters. Some kinds are too flexible to stand erect, and they hang from the coral ledges, as in the coral caves, in gorgeous clusters of scarlet, yellow, and crimson. All these corals are covered with cells, and each represents the dwelling

place of an individual polype. In some of these the diameter of the expanded rays or tentacles of the polype is about one-eighth of an inch; in others, as the astræa, nearly an inch. The rays, when expanded, closely resemble the petals of flowers, and coral flowers is, with many persons, a more familiar term than "rays," and equally expressive. The astræas have sometimes nearly a hundred petals or tentacles to a single animal. Others, as madrepores and porites, have twelve rays each; in

FIG. 10.



Madrepore; branching from Lateral Buds.

still other species a larger or smaller number is found. The rays or tentacles readily fold inward over and into the animal's mouth, and upon a slight jar of a mass of coral the waving tentacles close, and all motion or evidence of life disappears from its surface.

The number of polype-cells upon some species of coral is immense. A dome of astræa, twelve feet in diameter, with a cell to each half-inch of its surface, would contain 100,000 individuals. Prof. Dana remarks that a porites of the same size would number 5,500,000 polypes. But Agassiz states that he has estimated 14,000,000 individuals in a mass of porites not more than twelve feet in diameter.

Notwithstanding the enormous mass of some coral formations, they are dead and deserted throughout, excepting a thin crust upon the surface. This, in different species, may vary in thickness from $\frac{1}{8}$ or $\frac{1}{16}$ of an inch to half an inch, and constitutes the living portion of the

coral where the work of growth goes on. The inner or dead portions constitute the stony mass on which new material is secreted, but is no more essential for that purpose than a rock or a sandy shore. Prof. Dana observes that, if the living portion could be separated, it would form a hemispherical shell about half an inch thick. As the higher orders of trees increase in size by additions of new wood at the outer margin of the trunk, long after the heart-wood is dead, so the coral is alive and grows only on its surface.

It is obvious that the increase of the coral will continue without

FIG. 11.

Alcyonoid Polypes; "gayest and most delicate of coral shrubs."

limit except from surrounding conditions. Thus, if the dome reaches the surface of the water, the polypes die, and growth ceases in that direction; but it may increase in diameter, forming some remarkable structures, which we will presently notice. But, if the coralline mass be continually sinking by a subsidence of the land on which it rests, the conditions of growth continue, and reefs of tremendous mass and thickness are formed.

The dead coral is always more or less porous, until the pores and polype-cells are filled by comminuted substance or the infiltration of carbonate of lime. Aided by chemical changes, the mass becomes solid coral-rock, and finally compact limestone, with few traces remaining of

the coral structure. In many of the branching, tree-like corals the stems are formed nearly solid as they grow, and are of great strength. In some of the massive species the surface cells occupied by the living animals are very shallow, measuring from one-sixteenth to one-fourth of an inch in depth. Underneath the polype is a floor or partition of coral secreted by the animal, and which separates the new from the old cell. Hence many corals, when split vertically, show a coarse cellular structure. In the life-and-death process of the polypes, animal matters remain confined in the old cells.

As the coral masses increase in size, it is evident that there must have occurred a simultaneous increase in the number of polypes. This fact is the more interesting, when it is known that a great coral dome may have arisen from a few, or perhaps from a single parent individual. During the long period of its growth, reaching through thousands of years, how enormous is the number of builders of it that have lived and died!

The rate at which corals grow is an interesting question, but not fully determined, for want of sufficient data. A single mass standing in clear water would increase more rapidly than corals in a reef. If at the rate of an inch in six years, a dome 20 feet in diameter would require about 1,400 years. Some species seem to grow more rapidly than this, but the increase of reefs is slower, notwithstanding additions from shells and other sources. On a coral-plantation, as a reef may be called, a portion is always unproductive. There are barren areas on the reef where sands or sediment destroy the polypes, and retard its growth. The investigations of Prof. Agassiz, at Key West, indicate a growth of about six inches in 100 years. He says: "If we allow twice that rate of growth, not less than 7,000 years would be required for the formation of the great reef at that place, and hundreds of thousands of years for the coral growths which form the peninsula of Florida."

After a careful estimate, Prof. Dana concludes that the growth of reefs, from increase of their corals, may be from $\frac{1}{44}$ to $\frac{1}{80}$ of an inch per year, and adds that, "whatever the uncertainties of calculation, is is evident that a reef increases with extreme slowness." It is a reasonable calculation that more than 1,000,000 years have elapsed since the foundations were laid of some of the great Pacific reefs.

An opinion prevailed formerly that the different species of corals occur in a reef in a uniform order of superposition—that each flourishes at certain depths of water, and not above or below that plane. The general fact is known that no important reef-building coral grows at a depth greater than 120 feet. Above that plane, all the work of coral architecture is carried on. Prof. Agassiz supposes that the range of different corals in depth is in part limited by pressure of the waters. At 32 feet depth, the animal is under a pressure of two atmospheres, and of more than four atmospheres at 120 feet. In this connection he

states that the astræas occur at the bottom of the reef. Next in order, the brain-coral, porites, madrepores, and on the surface the light, branching varieties which are the shrubbery of the coral world. This arrangement may occur where the bottom on which the reef stands is immovable, or has remained without change of level since the reef commenced. But how it could occur in a coral mass 2,000 feet thick, growth being limited to a depth of 120 feet, is not entirely obvious. In order to explain the enormous depth of coral-reefs upon the submerged lands of the Pacific, it is necessary to consider the further well-established fact, first suggested by Charles Darwin, that the lands and ocean-bed have gradually subsided. The subsidence has been often at the same slow rate that coral-reefs have increased by upward growth. It seems inevitable from this that the builders are at work on the upper portions of the reef; certainly it is here only that the work of elevation can go on. Summing up this subject, Prof. Dana says: "Reef-building corals of the different groups *grow together promiscuously* at different depths up to low-tide level. The largest astræas, mæandrines (brain-coral), porites, and other kinds, have been seen by the author, constituting the upper part of the growing reef." The coral polype flourishes only in the belt of warm waters which lies in and near the tropics. A temperature lower than 68° Fahrenheit is fatal to them. The great reefs abound and grow with greatest vigor in the zone of greatest heat.

Surrounding most of the tropical islands are two principal reefs, one fringing the shore; the other, called the barrier-reef, lying seaward, sometimes more than 15 miles from the land. The intervening space is often filled with minor reefs and a gorgeous wealth of coral vegetation.

Here lie immense platform-reefs, a shell of coral covering the bottom beneath the shallow waters. These together make up the coral-reef ground of the island. West of the two larger Feejee Islands are 3,000 square miles of reef-ground. New Caledonia has a reef along its western shores a distance of 250 miles. The great Australian barrier, lying east and northeast of that island, forms a broken reef, 250 miles in length. On these outer reefs the waves forever break, and here, where the plunge of the surf is most furious and persistent, the polypes flourish with greatest vigor, and open their many-colored petals to the life-giving waters, as do thirsty flowers to the welcome rain. On every dead space delicate moss-like and lichen-like corals quickly form their thin, hard crusts.

Outside the reefs there occurs, in many places, a coral growth alike curious and interesting. In isolated patches are found immense mushroom-shaped masses called coral-heads. One is described by Whipple, cited by Dana, standing in water 50 feet deep, near Turk's Island. Its trunk is about 15 feet in diameter, supporting a tabular mass 100 feet in diameter, the top being bare at low tide. When these corals reach the surface, growth in that direction ceases, but may

continue indefinitely around the margins. Thus, in many places, the tops of adjacent trunks have joined together, forming a coral floor resting upon arches and pillars built without axe or sound of hammer. In some parts of the reef-region, such united coral-heads cover large areas. A magnificent scene would be presented should the waters recede and leave bare these arches and columns. The ruins which "sentinel the desert" would not rival them in grandeur. To thread their avenues and sounding aisles would be the labor of a lifetime.

The illustration, Fig. 12, after a sketch by Prof. C. F. Hartt, in his "Geology of Brazil," is of an area of the sea off that coast, abounding in coral-heads similar to those described. "The corals," says Prof. Hartt, "grow in the open sea, and often rise 40 or 50 feet, and form what the natives call *chapeiroes* (signifying 'big hats').

FIG. 12.

Coral-heads off the Brazilian Coast.

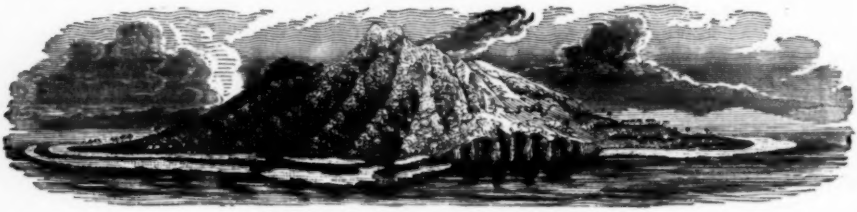
They are abundant on one part of the coast over an area of 40 square miles. A vessel running on the top of one of these chapeiroes would remain perched like a weathercock on the top of a tower, to the great amazement of the captain who finds deep water all around." Inside the outer or barrier reef the water is smooth as in an inland bay. If free from sediment, and not freshened by discharge from rivers, it is the paradise of the smaller corals. The beautiful fungia lie with innumerable shells upon the bottom. The feathery and fan corals grow in clusters, and, amid their delicate plumes, fishes, which rival them in gayety, glide through the transparent water.

It is a peculiarity of coral-reefs that the outer side is usually nearly perpendicular, while the inner side is a gentle declivity. The cause of this may be better understood if we follow the development of the reef from its beginning. Upon a shore of sand or rock, and at a depth of less than 120 feet, the reef-builders attach themselves

and commence to grow. The reef rises, but, as before remarked, corals grow most rapidly in the purest waters, and thus it is that reefs often seem to crowd against the waves without and assume a wall-like aspect. But, owing to the wash of the land within, and the discharge of streams in some instances, the polypes are less healthy and their growth more precarious. These causes modify the form of the reef. But, however modified, the reef fringes or encircles the land (Fig. 13). We have already remarked that coral-reefs can attain no greater thickness than about 120 feet, unless there occurs with their growth a simultaneous subsidence of the land on which they rest; but, with that coincidence, the growth of the reef may continue so long as the subsidence goes on.

It is obvious that, with this sinking of the land, the area of the island must diminish, the sea and its accompanying corals gradually encroaching upon its shores. At last the land disappears. Then we have a lake or *lagoon* over its former site, surrounded by coral-reefs – for the builders have not been at rest. All the features of coral growth continue, but the land with its wealth of vegetation is buried. A coral floor has formed over it. This is the history of hundreds, perhaps thousands of former islands in the Pacific alone; and the great reefs, from which the surf sends up an incessant wail, are the monuments of this ocean-cemetery.

FIG. 13.



High Island, with Barrier and Fringing Reef.

The encircling reefs, with the lagoon, are called an *atoll*, which is only another name for a coral-island. This effect is well shown in Fig. 14, page 271.

Moreover, the force of waves and lifting-power of water have broken fragments of coral and coral-rocks, and thrown them upon the reef. The mass may have been already weakened by the perforations of innumerable boring worms and mollusks which burrow in the reefs. Thus in places beaches have been formed 10 or 12 feet in elevation above the ocean. They are composed of coral sand made fine and drifted by waves and winds, fragments of shells, bones of fishes, and other matters drifted thither by the sea.

The beauty of the completed atoll must be given in Prof. Dana's words: "When first seen from the deck of a vessel, only a series of dark points is descried just above the horizon. Shortly after, the points

enlarge into the plumed tops of cocoa-nut trees, and a line of green, interrupted at intervals, is traced along the water's surface. Approaching still nearer, the lake and its belt of verdure are spread out before the eye, and a scene of more interest can scarcely be imagined. The surf, beating loud and heavy along the margin of the reef, presents a strange contrast to the prospect beyond. There lie the white coral-beach, the massy foliage of the grove, and its embosomed lake with its tiny islets. The color of the lagoon-water is often blue as the ocean, although but 10 or 20 fathoms deep, yet shades of green and yellow are intermingled." In some instances there is a ship-channel through the reefs into the lagoon, in others only a shallow passage, in others none at all.

FIG. 14.

Coral Island, or Atoll.

By a series of soundings, we have some idea of the depth of water near the ocean-side of many of the great reefs.

Seven miles from Clermont Tonnerre, of the Panmotus group, bottom was not found at 6,870 feet. From another point of the same island, only 1,500 yards from shore, the lead touched at 2,100 feet, then dropped off (probably from a projecting coral), and descended 3,600 feet without finding bottom. In another instance, about a cable's length from the island of Ahii (Peacock Island), in the same group, the lead struck at 900 feet, fell off and touched bottom at 1,800 feet. Off Whitsunday, 500 feet from the shore, no bottom was found at 1,500 feet. Deep soundings in the immediate vicinity of coral-islands is almost universal. Should these submerged islands of the Pacific be again elevated until their gigantic coral crowns should be lifted above the waves, an immense area of the Pacific would be converted again into an archipelago, not indeed of verdure-covered land as before, but of hills and mountains of coral-rock, bristling with crags, sublime with precipices and stupendous walls.

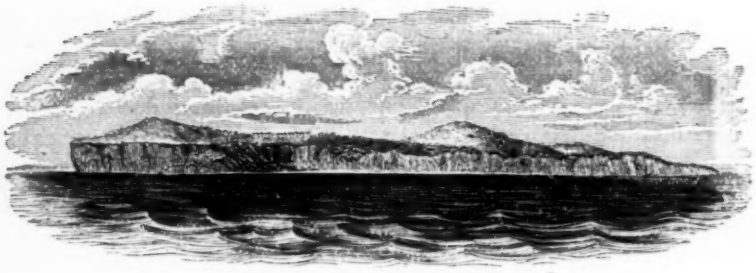
The great coral-bearing area of the Pacific is about 12,000,000 square miles in extent, nearly as large as the continent of Africa, or of Europe and North America combined. It extends from the southern side of the Hawaiian Islands to Pitcairn's Island to the southeast, thence 2,000 miles broad and 6,000 miles in length to the Pelew Islands, north of New

Guinea in the Polynesian seas. In this area are 204 islands, very few of which are high or with land still above the sea. Southward of this area are many mountainous islands, or with highlands, surrounded with reefs, evidently beyond the line of greatest subsidence.

The evidence is satisfactory that the depressed area has gone down, in comparatively recent geologic time, many thousands of feet, and yet the subsidence may have been less than the elevation of lands elsewhere; for we have the elevation of the Rocky Mountains, Andes, Alps, and Himalayas, modern events in geologic history. It is more than probable that great subsidence in one section is correlated by elevations elsewhere. And the depression of the Pacific area may correspond to the elevation of northern lands which probably caused the cold and glaciers of the glacial age. The movement was one of those great secular changes of the earth's crust which dates far back in its history.

There is evidence that the Pacific subsidence has ceased, or nearly so, and that local elevations have long since commenced. In about 40 instances, Pacific coral-islands have been elevated since reefs were formed upon them. Many of these elevations are a few feet only, others, a few hundred feet; as many as 600 feet in one or two instances. These elevated masses of coral-rock have the perpendicular walls and configuration before described. Metia, or Aurora Island (Fig. 15), is one of the Panmotu group; its walls of coral-limestone are 250 feet high, and resemble the Palisades on the Hudson.

FIG. 15.



Metia, or Aurora Island.

Along the outer margins of the elevated islands are deep caverns, showing, by their contour, the wearing and wasting action of waves. The Bermudas are remarkable for their caverns; the coral-made land being in places 260 feet above the level of the sea. On the island of Oahu, the Rev. John Williams entered one by a descent of 20 feet, and wandered a mile in one of its branches. Innumerable openings presented themselves on all sides. The roof, a superb stratum of coral-rock, 15 feet thick, was supported by stalactitic columns, and thickly hung with stalactites.

We cannot dismiss this subject without considering the coral-island, or completed atoll, in its relations to life. Upon an area so limited and so uniform, there may be much beauty, but little variety. On many of them there are less than a dozen species of plants, and not an animal higher in the scale than fishes, except a few migratory birds. Twenty-nine species of plants were found upon one island. There, as elsewhere, on the dry rocks, black lichens grow in patches. The germs of this class of plants seem to be present everywhere within the geographical limits of life. On some of the more favored islands are some tropical birds, a few rats and mice, and perhaps other animals introduced by man. The drift of the sea may convey to it various organic germs.

The coral-made land is ocean-born; its palm-groves were planted by the waves; and here too is man, savage, swarthy, unclothed, filthy, barbarous. With him degradation is an inheritance, and physical conditions hold him with relentless grasp. With occasional surfeit, he is in danger daily of starvation. He is driven to infanticide in self-defence. The taste which adorns our New-England landscapes can never develop here. In the land of the elm and the oak, rather than beneath the shade of the pandanus and the cocoa-nut palm, we must look for the conditions which mould manhood in the common struggle for life.

We quote again, and lastly, from Prof. Dana's work: "A coral-island, even in its best condition, is but a miserable place for human development, physical, mental, and moral. There is poetry in every feature, but the natives find this a poor substitute for the bread-fruit and yams of more favored lands. How many of the various arts of civilized life could exist in a land where shells are the only cutting instruments—fresh water barely enough for household purposes—no streams, nor mountains, nor hills? How much of the poetry and literature of Europe would be intelligible to persons whose ideas had expanded only to the limits of a coral-island, who had never conceived of a surface of land above half a mile in breadth—of a slope higher than a beach, or of change in seasons beyond a variation in the prevalence of rain?"

Such are coral-islands—beautiful gems of the ocean; delightful as a subject of study, equally in their aspects and development, their geological importance and in their relations to life.

THE PHYSIOLOGY OF EMOTION.

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THE object of this paper is, to examine the physical accompaniments of mental action, and, chiefly, to discuss the nature of the feelings or emotions which accompany the various conditions of body and mind; in fact, to lay down the theory that feeling (or emotion, which is another name for high and complex feeling) is the state which accompanies the excitation of a nerve centre or centres, being pleasant or painful according to the condition of the centre, or the intensity of the excitation.

Supposing this view to be correct, there is no need to allot one place in the brain to the intellectual and another to the emotional portion of the mind, neither can we discuss them apart. The intellectual or idea function, the thinking and working function of the mind, may be supposed to depend on the intercommunication of the nerve cells or centres of the entire hemispheres, carried on by means of the nerve-fibres, this interaction being accompanied by a feeling or emotion peculiar to the centres acting, but which varies according to their physical state at the moment of excitation, or that produced by the excitation itself.

That the cells, which in their aggregation make up what we call nerve-centres, vary immensely in their endowments and qualities, is a fact which probably few will dispute. We have centres of vision, centres of hearing, centres of taste and smell: the nerve-cells which form the intellectual centres of one who comes of a long line of educated and cultivated forefathers will differ from those of a descendant of Bushmen, even before they have been submitted to the influence of education. But, besides the special quality or endowment which each cell possesses, that quality which constitutes one a cell and centre of vision, as distinguished from another which is a centre of hearing, there is in each a varying state or condition on which depends its efficiency, its power of perceiving more or less accurately that which is presented to it, or of communicating with other centres of idea or motion. This condition will be influenced by a number of circumstances—by due nutrition, by heat or cold, rest or fatigue; but, according to it will be the efficiency or non-efficiency of the cell-function: by it, moreover, will be regulated, as I conceive, the pleasure or pain experienced when the cells are called into action. When the condition is sound and healthy, the function of the cells will be duly performed, and, in the due performance, pleasure, not pain, will be experienced. In other words, the supply of nerve-force being ample, the cells will energize pleasantly: when the nerve-force is insufficiently produced, or

by action is exhausted, the energizing will be attended with proportionate pain.

It may be a question whether "nerve-force" is the best term to apply to the condition I have spoken of. It is one which opens up the many controversies which exist, and have existed, as to the nature of force, the relations of the various physical forces, and of these to the forces which we see at work in living animals. While, on the one hand, some shrink away from the very name of force, and will none of it, as a metaphysical entity to be relegated to the schoolmen along with that other metaphysical entity, the "mind" itself, on the other, it is to be feared that men have imagined that the study of mental phenomena has, at length, attained to the rank of the exact sciences, because they have placed nerve-force in the same category and correlated group as light, heat, gravity, and electricity. "Animal combustion," says Mr. Bain, "maintains nervous power, or a certain flow of the influence circulating through the nerves, which circulation of influence, besides reacting on the other animal processes, muscular, glandular, etc., has, for its distinguishing concomitant, the mind. The extension of the correlation of force to mind, if at all competent, must be made through the nerve-force, a genuine member of the correlated group." It may be interesting to see in what way another distinguished philosopher connects the forces of purely physical phenomena with those of life and animal movement. In his work on Heat (p. 499), Prof. Tyndall writes: "The grand point, permanent throughout all these considerations, is that *nothing is created.* We can make no movement which is not accounted for by the contemporaneous extinction of some other movement. And, how complicated soever the motions of animals may be, whatever may be the change which the molecules of our food undergo within our bodies, the whole energy of animal life consists in the falling of the atoms of carbon and hydrogen and nitrogen from the high level which they occupy in the food to the low level which they occupy when they quit the body. But what has enabled the carbon and the hydrogen to fall? What first raised them to the level which rendered the fall possible? We have already learned that it is the sun. It is at his cost that animal heat is produced and animal motion accomplished."

When I speak of there being in each nerve cell or centre a condition, varying within certain limits, according to which it is capable of energizing more or less readily and pleasantly, I am far from intending to convey a notion of any metaphysical entity, even if I use the term "nerve-force." It is not possible to separate this force in kind from that which is the special property of the cell. Each cell, as it lives its life in our bodily organization, as it grows to maturity, and fades in its decay, separates and selects from the blood, by a molecular metamorphosis, that which it requires for its function as an idea-cell, a hearing, or a sight cell, but it separates it in varying quantity and

quality, and, having separated it, parts with it again, according to the demands made upon it. So this force, specialized by the various portions of the human brain, exists in every cell and centre, in greater or less degree, and upon the condition of its existence depends, it would seem, the pleasure or pain experienced when the part is called upon to act.

A cell, when it sets in action other cells, or other organs of the body, appears to deprive itself of this force, and in time to become exhausted, so that rest and repose are necessary for its renewal. If it be too metaphysical to talk of the conversion of bodily heat into force, and of force into muscular motion, it is, nevertheless, a fact of observation that a nerve-centre becomes exhausted by over-excitation and over-action, and, being exhausted, becomes incapable of energizing till its power or force is renewed by rest or food. In the following observations I shall try to illustrate the theory that a nerve-cell is called into action by stimulation applied to it from without, and that, according to its special quality, it will then energize and act upon other cells or structures. The *amount* of action, and the feeling attending it, depend on the condition in which it is at the time. And this condition will vary in proportion to its rest, nutrition, and heat, and also in proportion to the strength of the stimulation and the length of time during which it is carried on.

The first question is, By what method are we to gain any information upon these points? Absolute proof of what I have asserted is not to be expected; were it forthcoming, we should have learned it long ago. We shall have to apply the methods of observation and experiment, and, of these, observation will aid us most. We can observe the phenomena of Feeling in infants from the commencement of life, in children, in adults, in the aged. From mere sensations we can trace the dawn of what are called Emotions, or, to use an older terminology, Passions. We can observe them also in the lower animals, and in the varieties, so to speak, of man—in the savage, the insane, the idiot. And, in observing the feelings, we are compelled also to observe the outcome of them in the shape of bodily and facial motion, which is often the only evidence of their existence. Also, we shall observe the same individual under the various conditions of hunger and repletion, of sleep or want of sleep, of cold or heat, of health or disease. And we shall see how all the phenomena, which our inductive observation can collect, agree or disagree with the laws laid down by those who have by experiment investigated the physiology of the nervous system. From one method—dissection of the actual brain—we shall not learn much. When the action is over and the force departed, the actual structure teaches us little about the working. The greatest discoveries have been made by experimenting on living animals.

If we observe the life of an infant, we find it spent chiefly in sleep-

ing, its short waking-time being principally occupied in feeding, in accumulating the material for its structural and functional growth. Its acts consist of sucking, crying, and kicking, and of using to some extent its eyes and ears. It does not at first see any thing as an object; it merely undergoes the subjective sensation of light; its retina and sensory ganglia are stimulated by light; and, if the light be too bright and the stimulation too strong, it testifies the pain experienced, by contracting the eyelids and crying. On the other hand, it is pleased by being brought before a lighted candle or other gently-stimulating light. The acts very soon indicate pleasure or the reverse, and we know whether the child is pleased or not long before it can tell us. It is pained by cold or hunger or bodily suffering, by a too vivid light, by a loud or harsh sound, as it shows by crying, by movement of its body and facial muscles. Its pleasure is denoted by laughing, kicking, and corresponding movement and expression of face. It derives pleasure also from excitation of its centres of motion, from being tossed, dandled, and rocked, while rough and violent movements cause no less pain and discomfort. We see, then, in such a child, manifestations of a very considerable amount of feeling—feeling which is at this stage entirely bodily, or at the most sensory, arising from the exercise of the senses.

A little later, and we find that the child can discriminate between the voice and face of its mother or nurse and those of a stranger, deriving pleasure from the one and pain from the other, and evincing memory. It remembers what it sees and hears, and what it experiences; and as the original events were pleasant or painful, so are the recollections of them, as we learn from the manifestations it exhibits. We know nothing of a child's inner life except from these manifestations, for it tells us nothing. All we learn is from its *facta*, its acts; it does not yet talk, and, when it commences, its talk is only of concrete objects. It has no abstract terms or generalizations in its vocabulary.

If we trace the development of this child, we see how its pleasures and pains, which at first are entirely corporeal, merge by barely perceptible degrees into mental feelings, and how these expand from mere feelings into the emotions of adult life. Its feeling is being perpetually evoked by every thing that it sees and hears. By turns it displays anger, fear, pain, or delight, and the feeling called up by one object is only to be allayed by the substitution of another, which, stimulating another centre, will by such stimulation rouse another feeling. If we look at a boy of three years, healthy and strong, whose sleep and appetite are good, and whose nerve-centres are full of force, we see that his whole waking-time is employed in the keen enjoyment of spending his nerve-force in incessant motion and play. There is no work in him: his life is all active amusement, emotive movement. He exhibits rage, terror, jealousy, wonder, vanity, love, the desire for

action; and these emotions are fully developed and unmistakably exhibited. Here, then, we have the emotional part of our nature apparently full-grown, while the intellectual is yet in its early infancy. We know that it is in vain to reason with such a child: we control and manage him. These feelings are all expansions of the self-feeling which is plainly seen to be the feeling of the entire bodily organization. The child at first derives pleasure or pain from that which affects its bodily sensations, from the light or the color which pleases its sense of sight, from the song which gratifies its ear, from the warmth which is grateful to its skin, from the food which satisfies its stomach; and it extends its likings to those persons or things which minister to its comfort, its dislike to such as cause it discomfort, and so it displays its love, its hate and fear. These feelings are all reflected upon and through the medium of the body in facial and other movements. As the nerve-centres in which this self-feeling resides are roused and excited, so, according to the centre stimulated and according to the degree of stimulation, we have a corresponding series of movements as the result. There is a direct outcome of action, a direct conversion of force into motion, so to speak; without this we should not know that such stimulation had taken place.

How motion immediately follows the application of a stimulus to the centres is especially shown at this time of life. There is no deliberation, no delay; the action, the demonstration of joy, or sorrow, or resentment, or approval, is instantaneous. The motor centres respond to the stimulus as immediately as the pupil responds to the light, and the reflex action of the one is as purely physicial as that of the other. A child at this age possesses ideas formed from the memories of sensations and their associations, but its ideas are few, and it does not link them into chains of reasoning. Its intellectual processes are scanty, and so it comes to pass that the excitants of its nerve-centres are for the most part external events and sights, which at once result in bodily or facial demonstration rather than in internal mental action.

If mankind had stopped at the level of a child, if the higher and more complex emotions did not exist, it is not likely that various seats of emotion would have been mapped out in the brain. Emotion in children and animals is manifestly so much more a bodily excitation, the bodily movement follows so immediately as the result, that we do not confine it to a mental phenomenon as we do the higher emotions of man. But physiologically there seems to be no line of demarcation between simple feelings and the highest emotions. Before we examine the adult as we see him in the educated and refined inhabitant of the cities of Europe, we may pause and consider the various intermediate stages which carry on the succession from the child upward. There is the savage of all grades of savagery, from the Earthman to the stoical brave of North America who scorns to exhibit emotion of any kind. Many travellers have told us how like the tribes of Africa are

to children, how they display emotion in a similar manner, how they instantaneously respond to a stimulus, whether it call forth joy, anger, or grief. Then there is the uneducated and unenlightened pauper of many an agricultural district of our own land, and there is the idiot, and the insane, whose self-feeling is predominant, whose whole life is centred in self, as much as is the child's. If after these we consider adult and educated man, we shall see that his sensations, feelings, and emotions, each mental state, in fact, which is called up in his brain, may be, and for the most part are, attended with muscular movement voluntary or involuntary, indicating the pleasure or pain which accompanies the mental stimulation. The amount of movement will often be the measure of the amount of force extricated and emitted from the centre on the application of a stimulus.

The first thing we notice is that most of the emotions of man are the same in kind as those of children, or even the inferior animals, the same in kind, though varying in complexity and specialty, according to the infinite variety of the acquirements of the human brain. The emotion of admiration, awe, and wonder, which fills our breast on seeing some marvellous spectacle or hearing some great news, what is it but the wonder which we see depicted in the animal when it sees for the first time something entirely novel and strange? I once saw a leveret meet face to face a young dog in a covert. Probably neither had previously encountered such an object. They stood for a moment transfixed with surprise; this, changing in the hare to fear, caused it to turn and fly; the dog, not quite so timorous, pursued, his wonder being converted, by the leveret's flight, into the emotion of pursuit. The animal's emotions we recognize by its motions; we could not otherwise assert that it experienced emotions at all. Its brain, when stimulated, at once converts its force into motion. And, if we strictly analyze the feelings and emotions of man, we shall find that here also action or motion of some kind is almost invariably the concomitant of emotion —at any rate, when this is at all intense, or, as we rightly say, *powerful*. With regard to many of our feelings and emotions, this is at once apparent. If some sudden disaster occurs to a man, his countenance, probably his limbs, will denote his terror, grief, or anger. He is said to be devoid of feeling, if this be not the case. His mode of speech, his tone of voice, is affected by it, and he may be led into immediate and violent action, so involuntary that it may almost be called automatic. On the other hand, pleasant sights and news will produce corresponding traits in countenance and movements of limbs. The latter will be less marked than those set in motion by pain or grief, inasmuch as a pleasant stimulus will set up less violent action than one that is painful.

When we look at the simple emotions and feelings of man, we find him exactly on a par with the child or the animal. A violent stimulus produces at once violent, or at any rate manifest, action, facial or other. There is a conversion of nerve-force into muscular movement,

directly following a stimulus, whether this be one exciting bodily pain, as a blow, or mental, as a shocking sight or piece of news But, when we examine the mind of man in its highest development we find in the highly-intellectual individual certain emotions, which are clearly the feelings corresponding to the very complex ideas acquired and organized by years of culture and training. We read of the Ethical Emotion, or moral sense; of the Æsthetic Emotion; of other emotions arising out of the Intellect. But all these appear to illustrate and to be illustrated by what I have said concerning the simple emotions. Here, instead of a single and simple idea-centre which, when excited, at once responds in outward bodily movement, we have an extremely complex chain of ideas. The training and preparation of years, as well as previous organization, are required to bring about in the brain that complex series of ideas which represents a knowledge of the fine arts, and which is presupposed when we speak of experiencing æsthetic emotion. Instead of a single and lowly-endowed centre, such as we may find in children or animals, we have a coördinated and complex chain of high centres, which, when excited, respond not in immediate bodily movement accompanied by bodily feeling, but in deliberate action, the result of reflection; in intellectual, rather than bodily movement. For the activity of thought must be due to a stimulus applied to the intellectual centres, no less than the activity of body: and not only the activity of thought, but action in thought, the desire for action of body which would become action, did not some other reflection intervene, must also be set down as an outcome of nerve-force emitted by some centre or centres, which have been set in motion by a stimulus. Repressed action, whether in thought alone, or in the clinched hands and quivering lips of suppressed passion, must be taken as an emission of force. The complex coördination of ideas arrived at after years of study and experience, which causes the connoisseur the keen delight experienced when he gazes at a rare Rembrandt etching or a matchless coin, must include within itself the feelings belonging to it. The uninitiated cannot feel the delight, because he possesses not the ideas. We cannot suppose that the feeling resides in one part of the brain, and the ideas in another; rather would it appear that the stimulation of the ideas by the sight of the object causes the feeling. The ideas exist in the brain as knowledge, but when called into action we have the feeling of pleasure or pain which is special and appropriate to such a group of ideas, in addition to the knowledge and the ideas themselves. It may be said that emotions are so varied that they must require a special organization; that the emotion of delight just named is something totally different from such a feeling as self-denial. But we must remember that ideas are formed in the educated mind into large and complex groups—associated ideas, as they are called—and that these act as units, just as groups of muscles always act together; and the association of the

one, when established, cannot be disjoined, any more than that of the other. Consequently, stimulation of such a group of ideas calls it into action, and then arises its special feeling, depending in degree upon the amount of the stimulation and the nerve-force extricated in the process. And these very complex emotions may be reduced by analysis to much simpler feelings—to feelings of self-advantage or self-detriment, the pleasure or pain which is at the bottom of all feeling, of all stimulation of the nervous system strong enough to cause feeling to come into consciousness. Looking upon the whole conscious brain as self, its feeling varies from self-good to self-ill; its various and special portions, groups of nerve-cells and nerve-centres, being stimulated into special feelings which are yet all of them resolvable into the simple elements. If we look at the phenomena of insanity we shall see this illustrated by the fact that the feelings and delusions of the insane always have reference to self.

I have traced the higher emotions up from the mere bodily feelings, nay, even from the sensations of the special senses, and have affirmed that they all vary according to the amount of stimulation which each centre receives, while their quality depends on the special properties of the centre or centres. The phenomena of two of the senses, at any rate, confirm this view. One person hears a sound which another cannot. This is because the centre of hearing in the deaf person is not sufficiently stimulated by a sound, the vibrations of which are too slow for him, though not too slow for the other to perceive. Similarly, some people cannot recognize redness as a color. On analyzing the color red, we find it to be the color at one end of the spectrum, an inch of which gives the smallest number of waves of light, and to this amount of stimulation some eyes are insensible, just as the eyes of all men are insensible to the rays beyond red, which we discover by the galvanometer, though they do not excite our optic centres as light. As no two persons feel alike, so no two see or hear alike. The centres of sight and hearing of one man are stimulated by vibrations which fail to excite those of another. There may be colors and there may be harmonies all around us in the universe, of which we know nothing, but of which the more sensitive organs of what are called the lower animals may be keenly conscious. It may be that these animals are only by us called dumb because we ourselves are deaf.

The stimuli, then, which excite the nerve-centres of man, produce various feelings and emotions according to the quality and properties of the centre excited. But, as I have said, the feeling will vary according not only to the quality of the centre, but also according to the condition it may happen to be in at the time, or that to which it may be brought by the stimulation it experiences. To elucidate this, we must consider what we know of the physiology of nerve-structures and their functions.

When studying the physiology of nerve-action as we see it in animals, children, and men, and the pathology as we see it in various nervous disorders, as acute insanity, *delirium tremens*, and the like, we soon become aware of the fact that the well-being of the entire nervous system depends mainly on its renovation during a state of repose; and that for the higher portion of the brain, at any rate, this state of repose and rest is synonymous with healthy sleep. Round the phenomena of sleep, and its causes and conditions, are grouped many of the problems which have to be solved by the physiologist who has to investigate the action of the nerve-centres, and the physician who has to cure their disorders. The state or condition of a nerve-centre, which I have called the force, will be dependent upon the amount of rest and sleep which it enjoys, supplemented by two other restorers of force, food and warmth; which must also be taken into consideration.

Observation teaches us that all animals sleep after a certain period of bodily fatigue, which varies according to the individual, the young requiring sleep more quickly than the old, and a larger amount. If the fatigue be great, nothing can keep a child or even a man awake. When refreshed by sleep, when the force is again accumulated in the brain, we wake spontaneously, or are awakened by trifling stimuli, as sounds or light. This alternation of sleep and waking is the normal state of health, and absence of sleep is something abnormal: it is a disorder, and must lead to further disorder if prolonged. Sleep is not necessary for the renewal of force in every centre. In very severe muscular exercise mere cessation for a time recruits our force, and enables us to begin again; but for the higher work of the brain sleep is indispensable, and all brain-work, and indeed life itself, must cease, unless by this the force is renewed.

So much does observation teach us of the reparation of the force of the brain during sleep. Experiment, however, enables us to state the physiological condition of the brain in sleep, and so to analyze further the production and expenditure of this nerve-force. In sleep, as we have seen, it is produced and accumulated; in active waking hours it is expended. In sleep, the arterial circulation of the brain falls to a certain point, and metamorphosis consequently is reduced to a minimum. When the brain is acting, even in dreams, the blood-flow increases both in arteries and veins. To promote sleep, we seek to diminish this arterial current; until this is done, sleep comes not. The two things which chiefly produce sleep in a healthy man or animal are fatigue and food. After a hearty meal, or after great fatigue endured for many waking hours, it will be difficult to rouse him from sleep, and when roused he will be torpid and inactive, and will fall back into sleep easily. His brain will be emptied of blood, and ordinary stimuli, as light, sound, and movement of others, will not bring back the blood to his brain: moreover, his blood will contain less

oxygen. When sufficient hours have been passed in sleep, slight stimuli are enough to wake him, such as a trifling noise or a light; nay, he may wake or seem to wake "of his own accord." The blood returns to the brain highly oxygenized, and the brain is alive and energetic, ready to expend in action the force it has accumulated in the period of its rest.

Now, be it observed, this force is accumulated by the brain in sleep, when the blood-supply is at its minimum and contains the least oxygen. Oxidation of brain, then, implies expenditure, not accumulation of force. Stimulation of brain increases the blood-flow and activity, *ubi stimulus ibi fluxus*. But this activity cannot go on long, and material for new work cannot be provided, unless the blood-flow be reduced to the sleeping-point, and the oxygen in the blood cease to be consumed.

In the creation and restoration of nerve-force, food and heat are to sleep both the supplement and the complement; without all these the full energy of brain-life cannot manifest itself, except for a very limited time, and each will vary in amount according as the other two are supplied in greater or less quantities. To resist the cold of a northern climate, the Esquimaux consumes at a meal that which would feed a Hindoo for a month. If he did not, the bitter winter would bring to him, no less than to the animals hybernating around him, sleep from which he would not wake again. The intense desire for sleep felt by persons exposed to great cold is closely akin to that produced by overwhelming fatigue: the whole nerve-force is consumed in either case and cannot be replaced. In those suffering from cold, the loss may be met by warmth or by food; in those worn out by fatigue, sleep alone is the restorer. How completely the brain is upset by cold we may learn from the striking narrative of the Arctic voyager Dr. Kane,[1] who tells us, after a journey of eighty or ninety miles over the ice at a mean temperature of minus 41°.2: "We were quite delirious and had ceased to entertain a sane apprehension of the circumstances about us." "Our strength failed us, and we began to lose our self-control. . . We fell half-sleeping on the snow. I could not prevent it. Strange to say, it refreshed us. I ventured upon the experiment myself, making Riley wake me at the end of three minutes; and I felt so much benefited by it that I timed the men in the same way. They sat on the runners of the sledge, fell asleep instantly, and were forced to wakefulness when their three minutes were out."

The fact, that pleasure and pain depend on fatigue and the consumption of this nerve-force, is closely connected with two other phenomena: one, that the stimulation of any nerve-centre, if repeated, loses somewhat of its effect; the other, that the same stimulus, if prolonged or intensified, may cause every variety of feeling from

[1] "Arctic Explorations," i., 198.

pleasure to extreme pain. The first phenomenon is expressed in the language of every-day life, when we say there is nothing that we may not "get used to." We get used to sights, to sounds, to tastes, to smells, to the endurance of bodily pain. It may be stated as an almost constant fact that the same thing repeated, the centre again stimulated with the same stimulus, always loses somewhat of its effect, and consequently less force is expended. We endure the excitation better and feel less fatigued, whatever it be. If by any chance, however, through illness or other cause, our stock of force becomes lessened, we find that we cannot so well endure our habitual stimuli, and they become painful instead of pleasant. Our feelings, then, are regulated partly by the amount of stimulation, partly by the condition in which our centres are when stimulated; and that which applies to pain applies also to pleasure. Pleasurable excitations when repeated lose their charm, or they fail to please us when a disordered liver or a headache makes us dismal.

The second phenomenon is different. Although an excitation repeated loses its effect, yet an excitation prolonged without cessation passes from pleasure to pain without this process ever being reversed.

There is no voluntary action, whether mental or bodily, which does not in time cause fatigue; but it will be found that actions accompanied with direct emotion fatigue the soonest. Almost all bodily or mental processes are accompanied by some amount of feeling or emotion. They are pleasant to us or distasteful; we may be wearied of doing them, or wearied by doing them, according as the mind or the body is fatigued. In either case the process is the same, though the centre which experiences the discomfort is different. The pleasantest occupations or amusements may cause such sheer bodily fatigue that we can do them no longer, and to attempt it causes pain. It would appear that every thing carried to this point—to the extent of exhausting the nerve-force of the centre stimulated—causes discomfort or pain, which is only to be removed by cessation of the particular stimulus, and the substitution of another, stimulating other centres, or by the rest of the whole nervous system. This brings me to the consideration of another point, namely, that violent stimulation of a centre exhausts the nerve-force, not of that centre only, but of the whole nervous system. A terrible shock may so use up the nerve-force that the individual falls senseless, or, short of this, he may yet be so paralyzed with fear or grief that he loses all muscular power, or he may be so violently moved that the great exertions which he makes only last for a short time. We all know that for a long-sustained muscular effort the mind must be tranquil, and free from emotion, and the muscular movements must be regular and even, and free from spasmodic and violent action. How it is that the nerve-force of the whole system is poured out in this or that form of emotion, or idea, we see, but cannot trace the process.

Nevertheless, it is a fact that two great displays of force cannot coexist; violent muscular exertion and intense thought cannot go on together; the thinker sits, or stands, abstracted, motionless. The man who is rowing or running a race cannot command his thoughts; ideas come and go through his mind, but he cannot keep up a continuous current of mental work. His force is being expended on bodily movement.

What is the answer to those who say they believe that emotions reside in this or that part of the brain? We may object, first, that every attempt to locate emotions has signally failed, from the days of Gall, Spurzheim, and Combe, to those of Schroder van der Kolk. Some have separated the seat of emotion from the seat of the consciousness thereof, and have placed the latter in the sensory ganglia. Others have placed emotions in the hemispheres alone, and so would deny every thing of the kind to those beings which have no cerebral hemispheres; yet we see considerable emotional feeling manifested by such creatures as the ant and the bee.

Secondly, by an analysis of emotions we may perceive that there is no real line of demarcation between them and mere feelings of a much lower order, and that one and the other belong to the *action* of the moment, and not to any past or future time. If we are watching, say, a splendid sunset, we experience a feeling of intense delight as the heavens are lit in gorgeous color. The following day we may recall the scene, but we do not feel the pleasure. We remember the pleasure, but it remains, like the scene, only as an idea, it is not now a feeling. Now, few, I presume, would assert that the perception of this sight resides in one part of the brain, and the feeling attending it in another. If this were so, we ought to be able to excite the feeling by means of the idea preserved in the memory; but this we cannot do. The original stimulation causes the pleasure, and this vanishes, never again to return. It is only in complexity that the highest emotions differ from this simple feeling; they involve more ideas, more acquisitions, previously laid up, but the effect of the immediate stimulation is the same; this it is which, according to its intensity, causes the pleasure or pain. The same may be said of pain experienced; we may recall the memory of it, but this is not the same thing; even the memory may be distressing and saddening, but this is different from the acute pang which we suffer at the first shock.

The brain is a sealed book far more than some of the other organs of the body, as the lungs and heart; but, if we could inspect it at work, it is not probable that we should be able to note those molecular changes, which, nevertheless, we believe to take place when mental action is going on. What we should see, however, would be alterations in the circulation of the blood. We should see that the whole circulation, or portions of it, would be affected by mental excitation, by the stimulation of the various cells or groups of cells, which we call

nerve-centres. We should see that a piece of news, a disaster, an impending trouble or difficulty, causes a man to lay awake at night, and we should know that he lies awake because his brain circulation, either through the whole or in parts of his cerebral hemispheres, is higher than admits of sleep. There is an extrication of force going on in the shape of thought, there is a flow of blood going to the excited part. We cannot see all this, however, but we can and do see how emotion causes the face to flush and the pulse to quicken, how those who lie awake suffer from heat of head and suffusion of eyes, how emotion increases the lachrymal secretion, the lacteal, and others. And when we say that emotion does these things, we merely mean that something or other has stimulated the brain into producing these phenomena, and that along with the stimulus the feeling of grief or shame or anger coexists.

If all this be true, it may perchance throw some light upon many of the phenomena of disordered mind and brain: it may help us to understand why, with almost the same delusion, e. g., that the newspapers are writing about him, one man will be exultant, another angry, another depressed; it may explain why the same man is at one time maniacal, at another melancholic. Lack of force may account for the wretched feeling of the hypochondriac and the hysterical, for the mental pain which many feel when they are below par: and a proneness to part with force, to convert it into action, may be the condition of the centres of those who are excitable and impulsive, a condition analogous to that brought about in certain centres by such drugs as strychnia, by such diseases as epilepsy and convulsions, or evidenced by such an affection as stammering.—*Fortnightly Review.*

A GIANT PLANET.

By RICHARD A. PROCTOR, F.R.A.S.

WE propose to give a brief sketch of what is known respecting the noble planet Jupiter. He is the giant of the solar system, himself the primary of a scheme of orbs whose movements resemble in regularity the motions of the planets round the sun. Much has been discovered during the last few years—nay, even during the last few months—to render such a sketch interesting.

We must, in the first place, dispossess ourselves of the notion, not uncommonly entertained, that Jupiter is one of a family of orbs, nearly equal in dignity and importance, and comprising the Earth and Venus, Mars and Mercury, among its members. This idea still prevails, be-

cause in our books on astronomy we commonly see a set of concentric circles at regularly-increasing distances, assigned as the paths of the several planets of the solar system. And besides, there yet remains, in the modern teaching of astronomy, a perceptible trace of the ancient astronomical systems, in which Saturn and Jupiter, Mars, Venus, and Mercury, played parts of equal importance.

Let it be carefully remembered, then, that the four planets which circle nearest the sun—the family of which our earth is a member—differ in all their characteristics from the outer family (also consisting of four planets) to which Jupiter belongs. The whole of the inner family—the whole of the space within which its members travel—could be placed between the paths of Jupiter and his next neighbor Saturn, with a clear space many millions of miles wide on either side. The actual area between the paths of Jupiter and Saturn exceeds nearly thirty times the whole area within which the four lesser planets pursue their paths. And, when we consider the dimensions of the four inner planets, we find a like disproportion. Four circles representing these orbs can be enclosed within a circle representing Uranus, the smallest of the four outer planets; yet even this circumstance does not adequately represent the enormous disparity between the two families of planets; for, in fact, the volume of Uranus exceeds the combined volume of all the inner planets upward of thirty times. We might adduce many other illustrations of the complete dissimilarity between the inner and outer families of planets; but what has been already stated will suffice for our present purpose. It will be evident that, in considering the members of one or other family, we must be prepared to meet with relations which differ not merely in degree, but in kind. We may thus, at the outset, dismiss from our thoughts the idea that the planet Jupiter is necessarily to be regarded as an inhabited world merely because the only planet we are actually acquainted with is inhabited. The latter circumstance may be an excellent reason for regarding Mars or Venus as the abode of life; but the analogy can no more be extended to Jupiter than to the fixed stars, which certainly are not inhabited worlds. We must, in fact, consider the physical habitudes of Jupiter independently of all conceptions based upon terrestrial analogies. Studied thus, he will be found, as we conceive, to hold a position in the scheme of creation differing considerably from that which has been assigned to him, until of late, in treatises on astronomy.

It is necessary briefly to state the dimensions, mass, and general characteristics of the planet, before proceeding to discuss its probable physical condition.

Jupiter has a diameter exceeding the earth's rather more than ten times, and a volume exceeding hers 1,230 times. It is not far from the truth to say that Jupiter's dimensions exceed the earth's in very nearly the same degree that those of the sun exceed Jupiter's. But his mass, though gigantic compared with the earth's, does not altogether

correspond to his bulk, for it exceeds the mass of the earth only three hundred times. So that, if the disk our astronomers see and measure actually represents the true globe of the planet, his substance must be, on the average, much less dense than that of the earth. In fact, while the earth's density is nearly six times as great as that of water, the density of Jupiter (*thus judged*) would exceed that of water by barely one-third. This vast globe rotates, in less than ten hours, on an axis nearly upright or square to the level in which the planet travels. This rapidity of rotation—so great that points on the planet's equator travel twenty-seven times as fast as points on the terrestrial equator—results in a considerable flattening of the planet's globe; insomuch that the polar diameter is less than the equatorial by about a twelfth part, or by fully 7,000 miles. And it may be remarked in passing, that this circumstance—the fact, namely, that the poles of the planet are drawn in, as it were, 3,500 miles as compared with the equatorial regions, or 1,750 miles as compared with the mid-latitudes in either hemisphere—affords a striking illustration of the enormous amount of energy really represented by the rotation of Jupiter. It may also be added that the velocity with which points on Jupiter's equatorial zone are carried round, exceeds the corresponding velocity in the case of all the planets in the solar system, and is nearly six times greater than the equatorial velocity of the sun himself. It amounts, in fact, to about 7½ miles per second.

We do not propose to consider here at any length the system of satellites over which Jupiter bears sway; but this preliminary sketch would be incomplete without a few words on the subject. It is worthy of notice that, although our earth in some sort resembles the outer planets in being accompanied by a satellite, yet the relation which our moon bears to the earth is altogether different from that which the satellites of the outer planets bear to their respective primaries. Our moon is by no means a minute body by comparison with the earth, and compared with Mars or Mercury she may be regarded as having very respectable dimensions. We may, indeed, look upon the moon as a fifth member of the inner family of planets—a member inferior to the rest, doubtless, but still not so far inferior to Mercury as Mercury is inferior to the earth. In the case of the outer planets, however, and especially in Jupiter's case, moons hold an utterly subordinate position. Taking the accepted measurements, we find the largest of Jupiter's moons less than the 16,000th part of its primary as respects bulk, while its mass or weight is less than the 11,000th part of Jupiter's.[1]

[1] It is not uncommonly stated in our text-books of astronomy, that the density of Jupiter's moons is far less than Jupiter's density; and Lardner goes so far as to say that "the density of the matter composing these satellites is much smaller than that of any other body of the system whose density is known." But this is a mistake. All the satellites, save one, are of greater density than Jupiter, and that one—the innermost—is denser than Saturn, Uranus, or Neptune.

So that these orbs may fairly be regarded as bearing the same relation to their primary that Jupiter himself bears to his primary—the sun. It will be seen presently that this consideration is an important one.

But the great interest of the study of Jupiter resides in the fact that, being the nearest of the outer family of planets, the aspect of his globe supplies the best available means of determining the condition of the giant orbs constituting that family.

The first feature which strikes us in the telescopic aspect of the planet is the presence of a series of belts, lying parallel to the planet's equator. Usually the equatorial regions are occupied by a broad, bright belt, of a creamy-white color, and bordered on the north and south by copper-colored belts. Beyond these, again, lie alternate bright and dark belts, the dark belts growing more and more bluish in hue as the pole is approached—while the poles themselves are usually of a somewhat decided blue color in telescopes adapted to display such features to advantage. There are commonly two or three dark belts on each hemisphere.

Now, before inquiring into the peculiarities presented by these belts, and into the remarkable changes which have been noted lately in their general aspect, it may be well for us to consider briefly what such belts seem to imply. That they are due to peculiarities in the planet's atmosphere is admitted on all hands. And it has been usual to compare them with the trade-wind zones and the great equatorial calm zone on our earth. The bright belts, according to this view, are regarded as zones where for the time clouds are prevalent, the dark belts being regions where the comparatively dark hues of the planet's surface are brought into view. And then it has been deemed sufficient to point out that the parallelism of the zones is due to the extreme rapidity of the planet's rotation.

But, setting aside the fact that the trade-wind zones and the great equatorial calm zone on our earth are, in reality, little better than meteorological myths, it must be regarded as a remarkable fact that, in the case of a planet so far away from the sun as Jupiter is, there should be a supply of clouds so abundant as to form belts discernible from the earth. Jupiter is rather more than five times farther from the sun than the earth is, and receives from him about one twenty-seventh part of the light and heat which falls upon the earth (equal surface for equal surface). Making every allowance for the possibility pointed out by Prof. Tyndall, that some quality in Jupiter's atmosphere may prevent the solar heat from escaping, and so cause the climate of the planet to be not very different from the earth's, yet the direct heat falling on the planet's oceans cannot be increased in this way—nay, it must be rather diminished. It chances, indeed, that the very quality by which the earth's atmosphere retains the solar heat is unquestionably possessed by Jupiter's atmosphere. When our air is full of aqueous vapor (invisible to the eye), the escape of heat is prevented,

as Tyndall has shown, and thus the nights are warmer than where the air is dry. Now, in Jupiter's atmosphere there is much water, for observers, armed with that wonderful instrument, the spectroscope, have recognized the very same dark bands upon the spectrum of the planet which appear in the solar spectrum when the sun is low down, and therefore shining through the lower and denser atmospheric strata. The spectroscopist knows that these bands are due to the aqueous vapor in the air, because Janssen saw the very same bands when he examined the spectrum of a powerful light shining through tubes filled with steam. So that there is the vapor of water—and that, too, in enormous quantities—in the atmosphere of Jupiter. But though we thus recognize the very quality necessary for an atmosphere which is to retain the solar heat, our difficulty is not a whit lessened; for it is as difficult to understand how the invisible aqueous vapor finds its way thus into the planet's atmosphere, as to understand how the great cloud-masses are formed.

Aqueous vapor in the atmosphere, whether its presence is rendered sensible to the sight or not, implies the action of heat. Other things being equal, the greater the heat the greater the quantity of watery vapor in the air. In the summer, for instance—though many imagine the contrary—there is much more of such vapor in the air than there is in winter, the greater heat of the air enabling it to keep a greater quantity of the vapor in the invisible form. In winter, clouds are more common, and the air seems moister; yet, in reality, the quantity of aqueous vapor is reduced. Now, it cannot but be regarded as a remarkable circumstance that, though the sun supplies Jupiter with only one twenty-seventh part of the heat which we receive, there should yet be raised from the oceans of Jupiter such masses of clouds as to form veritable zones; and that, moreover, *above* these clouds there should be so large a quantity of invisible aqueous vapor that the spectroscopist can recognize the bands of this vapor in the planet's spectrum.

Even more perplexing is the circumstance that the cloud-masses should form themselves into zones. We cannot get rid of this difficulty by a mere reference to the planet's rapid rotation, unless we are prepared to show how this rotation is to act in forcing the cloud-masses to become true belts. The whole substance of Jupiter and his whole atmosphere must take part in his rotation, and to suppose that aqueous vapor raised from his oceans would be left behind in the upper air, like the steam from a railway-engine, is to make a mistake resembling that which caused Tycho Brahé to deny the rotation of the earth, because bodies projected into the air are not left behind by the rotating earth. Nor is it conceivable that belts which vary remarkably, from time to time, in position and extent, should be formed by sun-raised clouds in the Jovian atmosphere, if the planet's surface is divided into permanent lands and seas.

But we are thus led to consider a circumstance which, as it appears to us, disposes finally of the idea that in the cloud-rings of Jupiter we have to deal with phenomena resembling those presented by our own earth.

We are too apt, in studying the celestial objects, to forget that where all seems at nearly perfect rest, there may be processes of the utmost activity—nay, rather, of the utmost violence—taking place as it were under our very eyes, and yet not perceptible save to the eye of reason. Looking at Jupiter, under his ordinary aspect, even in the finest telescope, one would feel certain that a general calm prevailed over his mighty globe. The steadfast equatorial ring, and the straight and sharply-defined bands over either hemisphere, suggest certainly no idea of violent action. And when some feature in a belt is seen to change slowly in figure—or, rather, when at the end of a certain time it is found to have so changed, for no eye can follow such changes as they proceed—we are not prepared to recognize in the process the evidence of disturbances compared with which the fiercest hurricanes that have ever raged on earth are as mere summer zephyrs.

Indeed, the planet Jupiter has been selected even by astronomers of repute as an abode of pleasantness, a sort of paradise among the planet-worlds. There exists, we are told, in that distant world, a perennial spring—"a striking display of the beneficence of the Creator," says Admiral Smyth; "for the Jovian year contains twelve mundane years; and, if there were a proportionate length of winter, that cold season would be three of the earthly years in length and tend to the destruction of vegetable life."

Even those who have denied that Jupiter can be the abode of life, and have formed altogether unfavorable ideas of his condition, have pictured him nevertheless as the scene of continual calm, though the calm is, according to their view, the calm of gloom and desolation. They recognize in Jupiter an eternal winter rather than a perpetual spring. Whewell, for example, in that once famous work the "Plurality of Worlds," maintained that, if living creatures exist at all in Jupiter, they must be wretched gelatinous monsters, languidly floating about in icy seas. According to him, Jupiter is but a great globe of ice and water, with perhaps a cindery nucleus—a glacial planet, with no more vitality in it than an iceberg.

But when we begin to examine the records of observers, and to consider them with due reference to the vast proportions of the planet, we recognize the fact that, whatever may be Jupiter's unfitness to be the abode of life, it is not of an excess of stillness that his inhabitants (if he have any) can justly make complaint. Setting aside the enormous activity of which the mere existence of the belts affords evidence, and even regarding such phenomena as the formation or a disappearance of a new belt in two or three hours as merely indicative of heavy rainfalls or of the condensation of large masses of invisible

aqueous vapor into clouds—there have been signs, on more occasions than one, of Jovian hurricanes blowing persistently for several weeks together at a rate compared with which the velocity of our fiercest tornadoes seems utterly insignificant. During the year 1860, a rift in one of the Jovian cloud-belts behaved in such a way as to demonstrate the startling fact that a hurricane was raging over an extent of Jovian territory equalling the whole surface of our earth, at a rate of fully 150 miles per hour. It is not too much to say that a hurricane of like velocity on our earth would destroy every building in the territory over which it raged, would uproot the mightiest forest-trees, and would cause in fact universal desolation. At sea no ship that man ever made could withstand the fury of such a storm for a single minute. And yet this tremendous Jovian hurricane continued to rage with unabated fury for at least six weeks, or for fully one hundred Jovian days.

But during the last two or three years a change of so remarkable a nature has passed over Jupiter as to imply the existence of forces even more energetic than those at work in producing atmospheric changes.

In the autumn of 1870, Mr. Browning (the eminent optician and observer) called the attention of astronomers to the fact that the great equatorial zone, usually, as we have said, of a creamy-white color, had assumed a decidedly orange-tint. At the same time it had become much less uniform in outline, and sundry peculiarities in its appearance could be recognized, which have been severally compared to port-holes, pipe-bowls, and stems, oval mouldings, and other objects of an unecclestial nature. Without entering into descriptions which could only be rendered intelligible by means of a series of elaborate illustrations, let it suffice to say that the bright edges of the belts bordering on this ruddy equatorial zone seemed to be frayed and torn like the edges of storm-clouds, and that the knots and projections thus formed often extended so far upon the great orange zone from both sides as almost to break it up into separate parts.

Now, without inquiring into the particular form of action to which these remarkable changes were due, we can see at once that they implied processes of extreme energy. For, every one of the projections and knots, the seeming frayed edges of narrow cloud-streaks, had, in reality, an extent exceeding the largest of our terrestrial countries. Yet their aspect, and indeed the whole aspect of the ruddy belt, whose extent far exceeded the whole surface of our earth, changed obviously from night to night.

Strangely enough, these interesting observations, though they were presently confirmed by several well-known students of the heavens, did not attract that full attention, from the senior astronomers of the day, which they appeared to merit. Several, indeed, of our leading astronomers were disposed to deny that any thing unusual was in progress, though none asserted definitely that they based this opinion on a care-

ful reëxamination of the planet's face. But quite recently one of the most eminent of our modern observers—Mr. Lassell, lately president of the Royal Astronomical Society—(having been led to observe the planet by the fact that certain phenomena of interest in connection with the satellite-system are now in progress), found his attention attracted by the marvellous beauty of the colors presented by Jupiter's belts. After describing the appearances he had intended to observe in the first instance, he proceeds: "But this was not the phenomenon which struck me most in this rare and exquisite view of Jupiter. I must acknowledge that I have hitherto been inclined to think that there might be some exaggeration in the colored views I have lately seen of the planet; but this property of the disk, in the view I am describing, was so unmistakable that my skepticism is at last beginning to yield." Nor will this statement be thought to express more than the truth, when we add that, in the picture accompanying his paper, Mr. Lassell presented the equatorial zone as brown-orange, and three neighboring dark zones as purple; one of the intermediate light belts being pictured as of a light olive-green.

Let us compare these observations made in our brumous latitudes with those effected by Father Secchi with the fine equatorial of the Roman Observatory. "During the fine evenings of this month," he wrote last February, "Jupiter has presented a wonderful aspect. The equatorial band, of a very pronounced rose-color, was strewn with a large number of yellowish clouds. Above and below this band, there were many very fine zones, with others strongly marked and narrow, which resembled stretched threads. The blue and yellow colors formed a remarkable contrast with the red zone, a contrast doubtless increased by a little illusion. The surface of the planet is actually so different from that which I have formerly seen, that there is room for the study of the planet's meteorology."

It appears to us that, when these remarkable changes are considered in combination with the circumstance that on *a priori* grounds we should expect the sun to have very little influence on the condition of the planet's atmosphere, the idea cannot but be suggested that the chief source of all this energy resides in the planet itself. The idea may seem startling at a first view, but, when once entertained, many arguments will be found to present themselves in its favor.

For instance, it does not seem to have been noticed, heretofore, as a very remarkable circumstance, if the Jovian belts are sun-raised, that they pass round to the nocturnal half of Jupiter and reappear again, with the same general features as before, and this often for weeks at a stretch. Even that remarkable feature whose changes led to the conclusion that mighty hurricanes were in progress, yet changed continuously and regularly during the Jovian nights as well as during the Jovian days, for one hundred such days in succession. This is perfectly intelligible if the seat of disturbance is in the planet itself, but it is per-

fectly inexplicable (as it seems to us) if the sun occasions all these meteorological changes in Jupiter, as he occasions all the changes which take place in our earth's atmosphere. The alternation of day and night, which is one of the most potent of all the circumstances affecting the earth's meteorological condition, appears to have no effect whatever on the condition of Jupiter's atmosphere!

Now, as respects the alternation of summer and winter, we can form no satisfactory opinion in Jupiter's case, because he has no seasons worth mentioning. For instance, in latitudes on Jupiter corresponding to our own, the difference between extreme winter and extreme summer corresponds to the difference between the warmth on March 12th and March 28th, or between the warmth on September 15th and on September 30th. Yet we are not without evidence as to seasonal meteorological effects in the case of the sun's outer family of planets. Saturn, a belted planet like Jupiter, and in all other respects resembling him, so far as a telescopic study can be trusted, has seasons even more markedly contrasted than those on our own earth. We see now one pole now another bowed toward us, and his equatorial zone is curved now downward now upward, so as to form two half ovals (at these opposite seasons), which, taken together, would make an ellipse about half as broad as it is long. As no less than fourteen years and a half separate the Saturnian summer and winter, we might fairly expect that the sun's action would have time to exert itself. In particular, we might fairly expect the great equatorial zone to be displaced; for our terrestrial zone of calms or "doldrums" travels north and south of the equator as the sun shifts northward and southward of the celestial equator, accomplishing in this way a range of no less than three thousand miles. But the Saturnian equatorial zone is not displaced at all during the long Saturnian year. It remains always persistently equatorial! Nothing could be more easy than the detection of its change of place if it followed the sun; yet no observer has ever suspected the slightest degree of systematic change corresponding with the changes of the Saturnian seasons. Or, rather, it is absolutely certain that no such change takes place.

It appears, then, that night and day, and summer and winter, are alike without influence on the Jovian and Saturnian cloud-zones. Can it reasonably be questioned that, this being the case, we must look for the origin of the cloud-zones in these planets themselves, and not in the solar orb, whose action must needs be largely influenced by the alternation of night and day and of the seasons?

But further, we find that a circumstance which had seemed perplexing, when we compared the Jovian belts with terrestrial trade-wind zones, finds an explanation at once when we regard the belts as due to some form of action exerted by the planet itself. For, let us suppose that streams of vapor are poured upward to vast heights and with great velocity from the true surface of the planet. Then such streams,

starting from the surface with the rational movement there prevailing, would be carried to regions where (owing to increase of distance from the centre) the movement due to the planet's rotation would be greater. They would thus be caught by the more swiftly-moving upper air and carried forward, the *modus operandi* being the reverse of that observed when an engine leaves a trail of condensed steam behind it; or, rather, it may be compared to what would take place if a steam-engine were moving in the same direction as the wind, but less swiftly, so that steam-clouds would be carried in front instead of behind.

Now, heat is the only form of force which could account for the formation of the enormous masses of cloud suspended in the atmosphere of Jupiter. And it seems difficult to conceive that the clouds could be maintained at a great height above the real surface of the planet, unless that surface were intensely hot—as hot perhaps as red-hot iron. If we supposed this to be the case, we should find at once an explanation of the ruddy aspect of the dark belts. Nor would the change of the great equatorial belt from white to red imply more than that, owing to some unknown cause, clouds had not formed during the last two years over the planet's equatorial zone, or, having formed, had been dispersed in some way. We need not even imagine a complete dispersion, since the best telescopes, and notably Mr. Buckingham's fine twenty-one-inch refractor, have shown always a multitude of minute cloud-like objects over the ruddy equatorial zone.

But the idea of a red-hot planet, or of a planet partially red-hot, will appear at first view too *bizarre* to be entertained even for a moment. We have been so accustomed to regard Jupiter and Saturn as other worlds, that the mind is disposed to reject the conception that they can be so intensely heated as to be utterly unfit to be the abode of living creatures.

This unwillingness to accept startling ideas is not to be altogether reprehended, since it prevents the mind from forming rash and baseless speculations. Yet we must not suffer this mental habitude, excellent though it may be in its proper place, to interfere with the admission of conclusions which seem based on trustworthy evidence. Let us, then, inquire whether the startling hypothesis to which we have been led by the study or observed facts may not be found to be in agreement with other facts not yet considered.

It will be obvious that, if the real globe of Jupiter is thus intensely heated, a portion of the planet's light must be inherent. Therefore we might expect that the planet would shine somewhat more brightly than a globe of equal size and similarly placed, shining merely by reflecting the sun's light. Now, two series of good observations have been made upon the luminosity of Jupiter. One was made by the late Prof. Bond, of America, the other by Dr. Zöllner, of Germany. According to the former, Jupiter shines more brightly than he would if he reflected the whole of the light falling upon him! According to the

latter, and more trustworthy series, Jupiter does not indeed shine quite so brightly as Prof. Bond supposed, but the planet yet shines *three times* as brightly as a globe of equal size would shine, if similarly placed, but constituted like Mars, and *four times* as brightly as such a globe would shine if constituted like our moon. Jupiter shines, in fact, very nearly as brightly as though he were constituted like one of our terrestrial clouds!

This result is highly significant. If Jupiter showed no belts and shone with a pure white color, we could explain it at once by simply regarding Jupiter as wholly cloud-covered or snow-covered (for snow and cloud shine with nearly equal lustre when similarly illuminated). But the great dark belts which occupy so large a proportion of the planet's disk altogether negative this supposition. We seem compelled to believe that some considerable portion of the planet's lustre is inherent.

Let us, however, proceed carefully here. We have to inquire first how far Zöllner's results can be trusted; and, secondly, whether they are corroborated by any independent evidence. Now, Zöllner carefully estimated the weight of his observations—we may say he jealously estimated their weight, for it must be remembered that he was in no way interested in securing a greater or less result, while he was greatly interested in so stating the value of his results that those who might succeed him in the inquiry should not detect any serious error in his estimate. But his opinion of the probable degree of error in his observations was such as scarcely to affect to an appreciable extent the statements we have made above. Taking Zöllner's lowest estimate of Jupiter's brightness, that statement remains appreciably correct.

And next as to corroborative evidence.

It happens that we have a very delicate means of measuring the degree of Jupiter's luminosity, as compared with that of other orbs similarly placed. For his satellites pass across his face, and nothing can be easier than to observe whether they appear darker or brighter than his surface.

It was an observation such as this which Mr. Lassell had made on the night when he noticed the ruddiness of Jupiter's great medial belt. By a singular chance Father Secchi made a similar observation during *his* researches, and the reader will see, when we have quoted the narratives of both these observers, that the comparative darkness of all four satellites will have been established. "The fourth satellite," says Lassell, "has begun again for a season to cross the planet's disk, and I have looked out for opportunities of observing its passages, and was favored on the night of the 30th December last by witnessing a part of its passage under circumstances more than usually propitious. On its first entrance it was scarcely to be distinguished from the edge, not appearing at all as the others do, as a round bright spot. As it advanced, it grew gradually manifestly darker than the surface of the

planet, and, by the time it had advanced a fourth of the way across, it had become a very dark if not a *black* spot—so dark, indeed, that, if I had looked at Jupiter without knowing any thing of the positions of his satellites, I should have said that a *shadow* (of a satellite) was passing. I remember having seen the like phenomenon many years ago; but my impression is that I had never seen the disk of the satellite so near to absolute blackness before. Of course, it is only by contrast that it can possibly so appear; and we have in this fact a striking proof of the exceeding brilliancy of the surface of the planet. In the same way, the solar spots, if not surrounded by the marvellous splendor of the sun's surface, would doubtless appear as brilliant objects."

Next let us hear Secchi's account. "On the evening of February 3d," he says, "I observed the transit of the third satellite and that of its shadow. The satellite seemed almost black when it was upon the middle of the planet's disk, and notably smaller than its shadow, which was visible at the same time; one would have estimated it at only one-half. In approaching the edge the satellite disappeared, and reappeared soon after, close by the edge, but as a bright point. This fact is not a new one for the other satellites, but for the third it is unique. This result shows also the great difference of luminosity at the centre and near the edge of the planet, a difference already confirmed by photography."

It is hardly necessary to point out how strikingly these facts illustrate and confirm Dr. Zöllner's observations. But they also supply fresh evidence of a very interesting nature.

Although a part of the difference dwelt on in Secchi's closing words may be ascribed to the oblique incidence of the light near the planet's edge, yet it does not appear to us that the whole difference can be thus explained. A difference so great that a satellite appears as a bright point close by the planet's edge, and almost black near the middle of the disk, suggests that the light near the edge is not reënforced by the inherent luminosity of our theory, that luminosity adding only to the brightness of the central parts of the disk. We would not insist too strongly on this inference, because the darkening due to oblique incidence is, under certain circumstances, very obvious to direct observation. But it seems to us that a portion of the difference should be referred to the inherent luminosity of the central parts of the disk. This being admitted, it would follow that the real solid globe of the planet is much smaller than the globe measured by astronomers; and that, therefore, instead of that amazingly small density which is so perplexing a feature of the planet's physical condition, Jupiter's globe may have a density equalling or exceeding that of the earth.

And, after all, let us remember that the theory that Jupiter is an intensely heated globe—a theory to which we have been led by the consideration of many observed facts, and which in its turn suggests very satisfactory explanations of other observed facts—would merely

show that, as Jupiter and Saturn hold an intermediate position between the sun and the minor planets in respect to size, so those giant orbs hold a corresponding position in respect of inherent heat. Roughly speaking, the earth is 8,000 miles, the sun 840,000 miles, in diameter, and Jupiter, with his diameter of 82,000 miles, comes midway between these orbs. Now, the sun is a white heat, and the earth gives out only what is called obscure heat; and, if Jupiter's globe is at a red heat, he again comes midway between the sun and the earth.

We should be led by the theory here maintained to regard the major planets which travel outside the zone of asteroids as in a sense secondary suns. So viewed, they could not be regarded as orbs fit for the support of living creatures. Yet, as each of them is the centre of a scheme of dependent worlds, of dimensions large enough to supply room for many millions of living creatures, we should not merely find a *raison d'être* for the outer planets, but we should be far better able to explain their purpose in the scheme of creation than on any theory hitherto put forward respecting them. Jupiter as an abode of life is a source of wonder and perplexity, and his satellites seem scarcely to serve any useful purpose. He appears as a bleak and desolate dwelling-place, and they together supply him with scarcely a twentieth part of the light which we receive from our moon at full. But, regarding Jupiter as a miniature sun, not indeed possessing any large degree of inherent lustre, but emitting a considerable quantity of heat, we recognize in him the fitting ruler of a scheme of subordinate orbs, whose inhabitants would require the heat which he affords to eke out the small supply which they receive directly from the sun. The Saturnian system, again, is no longer mysterious when thus viewed. The strange problem presented by the rings, which naturally conceal the sun from immense regions of the planet for years together in the very heart of the winter of those regions, is satisfactorily solved when the Saturnian satellites are regarded as the abodes of life, and Saturn himself as the source of a considerable proportion of their heat-supply. We do not say that, in thus exhibiting the Jovian and Saturnian systems in a manner which accords with our ideas respecting the laws of life in the universe, we have given irrefragable testimony in favor of our theory. The theory must stand or fall according to the evidence in its favor or against it. But, so long as men believe that there is design in the scheme of the universe, they will be readier to accept conclusions which exhibit at once the major planets and their satellites as occupying an intelligible position in that scheme, than views which leave the satellites unaccounted for, and present the giant planets themselves as very questionable abodes for any known orders of living creatures.—*Cornhill Magazine.*

THE MIGRATIONS OF MEN.

By PROF. A. DE QUATREFAGES.

TRANSLATED BY ELIZA A. YOUMANS.

IS it, then, in our country, in France, in the vicinity of Abbeville, or of Aurignac, that man first appeared? Now, he is found everywhere: did he arise everywhere? or was his original abode at some particular point of the globe, and did he afterward disperse in all directions? If this be so, where is the privileged spot which gave him birth? Such are the questions that arise after that of the antiquity of man.

There has been much discussion on these questions. It has been said, and some still say, that men have originated wherever we find them. But a more careful study, a more profound knowledge of the laws that regulate organic and living beings, leads to the opposite conclusion.

Observe that here we can no longer appeal to the sciences which hitherto have served as our guide. Anatomy and physiology teach us nothing concerning the place of man's origin, his first dispersion, or his original home. It is all the same with regard to physiology, whether man appeared at a single point, or whether he appeared at several points at the same time. To study these questions we must interrogate another order of ideas and facts, but without changing the method on that account. We must always recur to other organized and living beings. It is to botanical and zoological geography that we now appeal.

Plants and animals are not distributed by chance upon the earth. Their distribution is subject to precise laws; and, because living and organic beings in general obey the same laws, man ought to follow the laws of geography as well as animals and plants.

Now, these laws of botanical and zoological geography teach us that in certain parts the flora and fauna are characterized by certain species; that the globe is partitioned off into a certain number of provinces, that have their particular vegetables and animals. These are the kind of provinces that have been called *centres of creation.*

It is natural enough to ask if each centre of creation has not had its own particular man, as it has had its peculiar vegetables and its peculiar animals. Led astray by certain coincidences, more apparent than real, some naturalists have replied in the affirmative. But, whoever will examine the question closely, will find that this is an error; for this mode of reasoning makes man a single exception among all organic and living beings. Now, you know we do not admit the possibility of this. Man ought to obey the laws of geography as he obeys the laws of physiology.

I cannot enter into all the details required for the complete demonstration of this statement. I limit myself to two facts that I hope will suffice to convince you.

The first is: not a single species of vegetable, not a single species of animal, is found at the same time all over the globe.

The most wide-spread species occupied at first only a small part of the globe, and man must have carried with him not only certain vegetables but also certain animals, to have them as widely diffused as we find them in our day. Notwithstanding this intelligent and voluntary intervention, you well know that there are certain parts of the globe occupied by man in which neither the vegetables that have accompanied us almost everywhere, nor the animals which we habitually transport, can survive. Man, on the contrary, is cosmopolitan in every sense of the word; that is to say, we find him everywhere, under the ice of the poles, as under the equator.

Hence, if he had originated wherever we find him, he would constitute a single exception among all organic and living beings, whether vegetable or animal.

This reason, by itself, ought to make us accept at least this much: that man has, at all events, peopled a part of the globe by emigration.

But we may go much further; and always, by virtue of the law which I have just stated, we may say that he had his origin in one spot, and that a narrow one.

In fact, when we study animals, we find that the extent occupied by a species, what we call its habitat, is as much less extended as the species is more perfected, more elevated, in the zoological series.

Not only is this true of species, but of types themselves.

Thus, below man, the animal form which most reminds us of the human form is, you know, that of the monkey. Are monkeys among the number of the most widely-distributed animals? No. The monkey-type is found neither in very cold countries nor in the greater part of the temperate regions, but only in the warmest parts of the globe. Besides, a great part of Oceanica contains not a single monkey.

If, now, we no longer consider the type, the entire group of monkeys, but only the species which approaches nearest to us, we see it occupying an area more and more limited. America has not a single species of monkey in common with Africa and Asia. And, when we come to the most perfect monkeys—to those which, by reason of their great resemblance to man, have been called anthropoid, that is, with a human form—we see the area of their habitat is restricted still more and becomes extremely narrow. So the orang-outang, one of those species of monkeys which some have wished to make our ancestor, is found only in the isle of Borneo, or at most, perhaps, in the isle of Sumatra; the gorilla, still another of the species which comes nearest man in his general proportions, occupies only a small part of the western regions of Africa.

Now, man is everywhere, and still he is incontestably, even from the point of view of his body, very superior to the monkeys. He alone has true hands, those marvellous instruments which you know so well how to use; he alone possesses a brain of which the size of the skull attests the development. Without speaking of other characters, man is evidently superior to all species of monkeys by his hand and his brain.

Well, then, the monkey, which, although so distant from man, still comes nearest to him, occupies but a restricted habitat; while man, the superior being *par excellence*, has originated, you say, simultaneously everywhere! Evidently, gentlemen, to accept this interpretation of facts, will be to make him a single exception among all organized beings; and so, I repeat, we can never accept this conclusion.

So you see, we are led to admit, not only that man originated in one single place upon the globe, but further, that this was a limited region—of very small extent. It was probably not greater than the habitat now allowed either to the gorillas or the orangs.

Can we go still further? Can we determine the particular spot of the globe where arose this privileged species which was to go forth and conquer the whole earth? We cannot answer this question with the same confidence as the others. But we may answer it with great probability. According to all appearances, the point where man originated, and whence he emigrated to all parts of the globe, was situated somewhere in the centre of Asia.

The reasons which lead us to this conclusion are of many kinds. I can only indicate the two following:

Around the elevated central region that you see pictured upon the chart in the heart of Asia, we find the three fundamental types of humanity: the black man, the yellow man, and the white man. Black men are at the present time widely enough dispersed. We see them still, however, in the peninsula of Malacca and in the isles of Andaman. Again, we find traces of these blacks in the east of Asia, at the isle of Formosa, at the south of Japan, and in the Philippines: the Melanesia belong to them. The yellow race occupies almost all the southeast part and even the centre of Asia; and finally we know that from this elevated central region came the great white race which to-day rules everywhere—the Aryan race, that to which we belong. The groups, more or less pure, are besides related to each other by a multitude of intermediates which may be regarded as transitional.

It is not only by the features, by fundamental physical traits, that the men found around this immense table-land are interrelated, and seem to blend into one another. We see, furthermore, on the sides of this vast table-land, the three essential types of language—of the most striking intellectual manifestation of man.

We shall come to this question by-and-by, but to-day I may say to you that we distinguish three fundamental forms of human language:

monosyllabic languages, in which each word has but one syllable; agglutinated languages, in which the words are welded together; and, finally, flexible languages, which resemble the languages now generally spoken in Europe.

Now, we find around this central plateau of Asia the monosyllabic language, *par excellence*, all over the Chinese Empire; on the north an assemblage of peoples speaking agglutinative languages, and extending even to Europe. Then, again, we have the portion occupied by the Aryan race, speaking the flexible languages. So the three linguistic types are represented around this table-land of Asia, the same as the three fundamental physical types. It seems that, almost from his cradle, man has presented all the essential modifications that he could undergo.

I pass to another question. Man, starting from a single and limited spot, has spread all over the globe. Consequently, he has peopled the globe by way of emigration and colonization. Such is the conclusion drawn from actual facts interpreted by science alone. But, is it possible to people the earth by human migration? Some say no; and make this assertion an objection to the ideas that I have just indicated.

I own that, for my part, this objection has always surprised me.

Migrations—colonizations! why, they occur everywhere in his tory, and particularly in our own history.

Go back as far as we may, we see populations in movement from one end of continents to the other; so that, to say *a priori* that man has always lived where we find him, is to contradict all historical documents.

However, some have insisted that certain migrations were beyond human power and intelligence. I will give you two examples to show that migrations are always possible, even when the conditions in the midst of which they take place seem made expressly to arrest them.

We must distinguish, in migrations, those over land from those across seas.

As to migrations by land, it is very evident that, when men have to war only against brute Nature, nothing can prevent their passage, especially when they can choose their moment. But I add that men will emigrate, even when they have to combat all difficulties united, not only the rigors of physical Nature, but also the action of man, who alone absolutely arrests man.

For example, I will cite a fact borrowed from the history of a people of whom I here show you some drawings:

Toward 1616, according to Chinese dates, a horde of Calmucks, for some reason which we do not know, left the country bordering upon China, crossed the whole of Asia, and established themselves on the banks of the Volga. There they accepted the sovereignty of Russia, and for more than a century rendered good service to the empire. But there came a time when the Calmucks found that the Rus-

sian yoke was growing more and more oppressive. To throw it off, they decided to emigrate, and return to the country of their ancestors. The tribe had settled on either bank of the Volga, and, in order to come together at a determined place, it had been arranged to start in the dead of winter, at a time when the ice would be strong enough to allow the people on the right bank to gain the left bank of the river. On a given day, all the people of the left bank came together; but some unknown cause hindered the people of the right bank from crossing. The number of emigrants was, however, very considerable, for, including women and children, there were 250,000. The rear-guard was composed of a select body of horsemen, which counted 80,000 men. You see, here was an emigration of an entire people.

From the beginning of the journey, the leaders understood that they must hasten; for, at the first news of their departure, the Russians gave orders to pursue the fugitives. A regular army was soon organized and advancing upon them, preceded by a host of Cossacks. These sworn enemies of the Calmucks massacred all those that strayed away any distance from the main body. Although it was the 5th of January, 1771, when they started, this entire people traversed the regions here indicated, and arrived on the following September on the frontiers of China.

In this long journey of more than 700 leagues, this wandering horde was constantly pursued by the Russian army, obliged to advance always by forced marches, to open a passage through hostile countries, harassed not only by the Cossacks but also by the Kirgheez, and the Bashkeers, the most savage and warlike inhabitants of these countries, who gave them not a single moment's peace.

I forgot to say that the winter, always very severe in these regions, was exceptionally so at this time; that in the first eight days all the beasts of burden perished, and that they had to burn their tents to obtain a moment's warmth. The women, the children, the aged, and men in their vigor, perished by thousands from the cold. This journey was, in reality, for these people, what the retreat from Russia was for the French army; but with this difference, that the Calmucks emigrated in families, with women and children, so that the disaster would be much more terrible. Winter was followed by summer; and, much as they had suffered from cold, they suffered equally from heat, and, above all, from want of water. There was even a time when the entire body of Calmucks, at the sight of water, disbanded to quench the thirst that devoured them. The rear-guard itself yielded to the temptation. The Bashkeers and the Kirgheez, taking advantage of this disorder, fell upon the multitude and put them to great slaughter. Happily, Kien-Long was engaged in the chase in these parts, and, as is usual with the Emperors of China, he was accompanied by a real army, in which were several batteries of artillery. He fired some pieces of

cannon on the Kirgheez and the Bashkeers. The Calmucks recovered their coolness, defended themselves, and all that remained of these people were saved. The emperor immediately gave them some food and clothing; then he gave them the country which is occupied by their descendants at the present time.

I will add that Kien-Long caused a column to be erected on the spot where the encounter had taken place. On this column we read an inscription, in very simple words, recording how Kien-Long saved an entire nation. The inscription ends with these words: "Let this place ever be regarded as holy." Gentlemen, I cannot be deceived in saying that you will join in this prayer of one of the greatest sovereigns of China. The place where a nation has been saved merits consecration much more than that where the most brilliant victory has been gained at the price of thousands of human lives.

The hour passes, and I cannot enlarge upon this interesting question of migration as much as I intended. I will content myself with citing one example of migration by sea. It is still more striking, as it bears upon a race constantly referred to when it is wished to prove that men were born where we find them. At the present time, the part of the globe of which I am about to speak is one of those where the peopling by migration is most completely demonstrated. I mean Polynesia.

Here is Polynesia. You see that it occupies a good part of the great Pacific Ocean, and that it is included in a triangle whose sides, from the Sandwich Islands to New Zealand and to the isle of Pâques, measure, in round numbers, 1,800 leagues. The islands dispersed in this immense space are scarcely as much as a grain of sand in the Place de la Concorde. Several among them are smaller than Paris. The isle of Pâques in particular, which forms one of the extremities of the triangle, has precisely the extent of the city-wall of ancient Paris before the annexation of the suburbs—that is to say, 25 kilometres (15½ miles) in circumference.

You understand what in this vast sea an isle of these dimensions amounts to; and there are others much smaller, which are likewise peopled. The argument drawn from this situation would seem, then, to have great force. How do you suppose, says one, that savages, having no improved means of navigation, have been able to cross such spaces? Why were they not lost in this vast ocean before finding these small isles?

Unfortunately, I cannot go into the detail of facts to show you how inexact is this *a priori* reasoning. I will only say that at the present time we know not only that the people of Polynesia came from some other place, but that they came from the Indian Archipelago. We know, besides, what has been the general course of their migrations, and can trace them on the map. Further, we have been able to determine the epoch when they took place, relying on precise

documents, as positive as the charts on which we rely in writing the history of our middle ages.

These people came from Asia, from a point of the Indian Archipelago that we can determine approximately. They reached the Marquesas Isles in the beginning of our era, or in the years immediately preceding. We know with still greater certainty that the emigration to New Zealand, that is to say, to the most distant portion of Polynesia, took place in the beginning of the fifteenth century, and that the emigration from New Zealand to people the Isles of Chatham occurred scarcely a century ago.

Here we meet with a significant fact. When these emigrants established themselves in the islands of which we are speaking, they found them deserted. This circumstance singularly facilitated their new settlement. If the Calmucks, of whom I just sketched the history, suffered so much, it is because they found men on their route. In our day, if it is still difficult to traverse Africa—if the journey from Timbuctoo has cost the lives of so many courageous travellers—it is because the Tuaregs close the passage to us.

The more we study, the better we know that all over the surface of the globe man surmounts every difficulty, so long as he wars only against Nature. If he is arrested, it is when he encounters man. In a word, man alone can arrest man.

I wish to say a few words also on the last of the questions suggested by this subject.

Man, we have seen, took his departure from a particular place on the globe, and now he is everywhere. Consequently, in his long and multiplied journeyings, he has encountered climates the most extreme, and conditions of existence the most opposite. He has adapted himself to all. Does it follow that a new-comer, that a European for example, can establish himself anywhere on the globe and immediately prosper there? You know he cannot. He must become acclimated; and you can easily understand that it ought to be so. The human body, which has developed under certain conditions of existence, is in harmony with them. If they change, and above all if they change suddenly, it is evident that the entire organism receives a shock; and this shock brings with it suffering, that you know often ends in death.

Experience has shown that these sufferings have been more grave and frequent when the course of emigration has been from cold toward warm countries—whence a certain number of physicians and anthropologists have drawn the conclusion that there are some countries on the globe that the European cannot inhabit—in which he can never prosper and multiply Some have even gone further. They have maintained that men could only propagate where they were born; so that, in reality, the Frenchmân can only live in France, the Englishman in England, the Dutch in Holland, etc.

This exaggeration needs no refutation. It is already refuted by

the existence of our colonies. We know very well that there are some parts of the globe where the European is acclimated almost immediately; not that he can escape all sacrifices, but they are relatively few. I refer you to the case of Acadia, that country in Canada peopled by sixty French families, and which, in a very short time, counted its inhabitants by thousands. I may cite you also to what is passing every day at the Cape, in Australia, at Buenos Ayres.

You see, then, in both worlds, and under the most diverse climates, Europeans prosper, multiply, and work, as they do in Europe. Still there are places where the question is much more difficult of solution, and which have been considered fatal to Europeans. I will name in particular, on the western coast of Africa, our colony of Senegal, and above all that of Gaboon; I will point out, in America, the Antilles generally, and consequently Guadeloupe and Martinique; then French Guiana. Algeria itself has been a subject of lively debate from this point of view. It will seem natural to you that I should dwell a little more upon this last place, because of its special interest for all of us.

From the day of our conquest the question has been, whether the French could be acclimated on the soil of Algeria; and, curiously enough, friends and enemies, Englishmen and Frenchmen, military commanders and physicians, were almost unanimously agreed that it could not be done. They relied on the tables of mortality, which showed an excess of deaths over births. It is easy to see that a country, where the number of those who die gains on that of those who are born, is fated to become depopulated, unless new immigrants repair the annual losses. This is what was said of Algeria, and it is one of the points that I have had to discuss in my lectures.

Now, in spite of documents so often quoted, I do not hesitate to say that Frenchmen have been acclimated in Algeria, and have lived there very well. To arrive at this conclusion I have not denied the figures—the facts cited by those who reached the opposite one; on the contrary, I have accepted them. But I have interpreted them, resting on this principle, which we never abandon, namely, that, as regards his body, man is an animal and nothing else. Consequently, if the laws that govern animality bear heavily on him in certain circumstances, he profits, in return, by advantages that these same laws bring to animals.

Now, before studying the acclimation of man, I began by studying the acclimation of plants and animals. This study taught me that, from the moment when an organized species changes its environment, be it plant, animal, or man, it must be resigned to make two kinds of sacrifices: sacrifices bearing upon the individual, and sacrifices bearing upon the race. In Algeria, the former were shown by the figures of mortality of the army, which were much more considerable than in France. The latter were made apparent by the figures of mortality of children, which, in Algeria, were double those of France.

But I was aware that, when we Europeans tried to transplant to America certain species of domestic animals, the figures of mortality at first were much more considerable than those of the mortality of our army; that the figures of the sacrifices bearing on the race were much higher than those of the mortality of children in Algiers. However, to-day, those animals are acclimated in America, and prosper so well that certain species have run wild, and are, so to speak, become indigenous.

Relying upon these facts, I said, almost from the first of my lecturing, The time will come when Frenchmen will be acclimated in Algeria.

The event has justified me sooner than I hoped. Public documents this year, containing the quinquennial census, show, relatively to the preceding period, an increase of more than 25,000 souls. But, what is more important, they establish that this increase is almost entirely due to the excess of births over deaths.

So that the sacrifices of the French in peopling Algeria already begin to bear fruit; and certainly the time will come when that country, conquered by our armies, will be, for the descendants of our first colonists, as salubrious as France is for ourselves. Then Algeria will truly be the France of the South.

But the sacrifices which accompany colonization are none the less sad, and it is often asked if there are no means of diminishing them. Unhappily, this is always difficult, often impossible.

However, here are two facts that I ask you to reflect upon:

Some of our colonies have the reputation of being particularly unhealthy, and it is said that in them manual labor is impossible for Europeans. The worst of these are on the western coast of Africa. Now, listen to the statement of Captain Bolot, commanding a company employed in the construction of a pier at Great Bassam, made to Captain Vallon, from whom I drew the fact: "A single Sunday put more men in the infirmary than three days of work under the hot sun." This is because the Sunday was given, not to work, but to debauchery.

Captain Vallon profited by the experience thus acquired. In his cruises to Gaboon he maintained on board his ship severe discipline and regular work. When not at sea, he made the sailors of the Dialmate work regularly in the full sun, but he forbade all excess, and in this way he preserved his own health and that of his crew.

I will give you another and much more important example, as it constitutes a true comparative experience.

It is another of the colonies I referred to as devouring Europeans. I mean the Isle of Bourbon, at the east of Madagascar, almost under the tropics—on one of the warmest points of the globe.

The tables of mortality of this island show a frightful excess of deaths over births. Judged alone by these tables, we must admit that the inferences drawn are perfectly justified. But these tables are true

only when we take the population *en masse*. Now, the people composing it form naturally two parties. One includes the great proprietors, the great planters, the leading merchants, and all those who belong to them, who, so to speak, lead the life of colonists. It is to such, and to such alone, that the desolating figures referred to apply.

The other part of the population is composed of people who till the ground with their hands, and who are disdainfully called by the name of poor whites. These are the descendants of the first colonists, who were all too poor to buy slaves, too proud to enter into the service of others, and who accepted for themselves and their posterity the life of small farmers. This last population keeps very much by itself; it has multiplied, and not only become prosperous, but its physical type has improved so much that travellers all speak of the personal beauty, both of the men and the women, of this race.

So, in this same Island of Bourbon, the rich planter and the working-men in cities, perish from the life of excess and debauchery, for which they are too much inclined in the colonies. The poor whites, who devote themselves to the cultivation of the earth, which is said to be impossible for the European under the tropics, have continued to develop, and have gained in all respects, because they have joined to moderate labor a sober life and pure manners.

Gentlemen, there is in this fact a practical lesson. Perhaps some among you will leave France; perhaps you will go to the colonies or to Algeria to seek your fortune! Let me impress upon you the history of the poor whites of the Isle of Bourbon—they have found that, to maintain health of the body, one of the best means, undoubtedly, is to preserve the health of the soul.

ON THE DIGESTIBILITY OF VEGETABLE AND ANIMAL FOODS.

By PROFESSOR VOIT,

OF THE UNIVERSITY OF MUNICH.

(Abstract by M. André Sanson)

AT the session of the Munich Academy of Science, December 4, 1869, Voit detailed the chief results of investigations made in his laboratory by Drs. Bischoff, Förster, Hoffmann, and Meyer, students of medicine, as to the differences which exist between animal and vegetable substances in point of digestibility, both in the carnivora and human beings; and also as to the importance of nutritive salts and condiments. These results have such a bearing upon alimentary hygiene that we have thought it desirable to give an extended analysis

of this essay of the learned Bavarian physiologist. As the subject is important, we give a *verbatim* statement of the results.

Vegetable food, it is well known, contains, as its essential nutritive elements, albuminates, or nitrogenous materials, fatty matter, and hydrates of carbon, with water and nutritive salts. Such food, therefore, has the same elements as animal food; but in point of digestibility the two differ widely. Thus, while the carnivorous animal, when fed with sufficient flesh-meat, passes but little excrementitious matter, while it traverses the entire intestinal tract within eighteen hours after a meal; the herbivorous animal, on the contrary, when fed abundantly with vegetable substances, often retains the food in the intestine a whole week; and a considerable portion of this food remains unused. The proportion which the solid excretions bear to the weight of the animal is, for a dog fed on meat, as 3 to 10,000; for man with mixed food, 5 to 10,000; and for the ox, as 60 to 10,000.

We must observe that this difference is not due solely to the varying digestibility of the substances compared. These substances, as found in the excreta of herbivorous animals, are not such as resist the action of the digestive fluids. Henneberg and Stohmann have shown that the proportion of such substances digested depends upon their respective proportions in the sum of the food consumed. This is one of the most important recent contributions to the physiology of digestion. What renders vegetable food harder to digest is the fact that the albuminoid substances, fatty matters, starch, etc., are there incased in a coating of cellulose, to break up which requires some time. On this account, the intestine of the herbivora is longer and more complicated than that of the carnivora. The latter digest but a small proportion of cellulose. The same holds good for man, except when he consumes young cellulose but little consolidated, as tender pulse, roots, or fruits. The cellulose of hay and grass is of such quality that the human digestive apparatus cannot extract any of their nutritive elements. In order that we may utilize them, they must first be transformed by herbivora into their own substance.

Albuminates, whether derived from the animal or from the vegetable kingdom, leave but little alimentary residue. If fat be added to the albuminates, this residue is increased in proportion to the amount of fatty matter, especially when the latter is in excess. The addition of sugar, no matter in what quantity, has not the same result, provided it does not cause a diarrhœa. Of sugar, but faint traces are to be found in the residuum. With starch it is quite different, even when it is made pulp by boiling.

Adolph Meyer has made some interesting experiments in this matter. A dog was given 1,000 parts of bread per day (536 dry matter) and with such food his excreta amounted to 70 parts of dry substance. The equivalent of the albumen in the bread was then given, in the shape of flesh-meat, its starch being replaced by the respiratory

equivalent in the shape of fat (2, 4 : 1); consequently the sum must have been 377 meat, 184 fat. The dry excrement was then only 20, with five of fat. More albumen was, therefore, digested in the latter case than in the former, for in the excretory residue from the bread there was found of nitrogen 2.45, while in that from meat and fat it was only 0.97. To show that it is really the starch which yields excessive residue, and not some other constitutent part of the bread, Mr. Meyer gave the albumen of 1,000 parts of bread under the form of pure flesh-meat, and also starch in the form of fecula reduced to a pulp. The sum was 377 parts of meat and 522 of starch. This ration yielded 68 parts of excrementitious matter per day, as when the equivalent food was given in the shape of bread. Still these excreta contained less nitrogen than that from bread. According to the investigations made by Dr. Bischoff, more nitrogen was assimilated out of 302 parts of meat and 354 of starch, than out of 800 of bread, although in each case the quantity of albumen was equal. It is hence seen that it is the starch which gives the greater part of the rejected residue. It follows that carnivora and man living on vegetable food ought to evacuate the bowels twice a day; whereas, on an exclusive meat-diet, they might retain the intestinal contents for at least four days.

Bischoff thinks that, as the starch must first be transformed into sugar before it can be absorbed, there is not sufficient time for this change to be thoroughly brought about, before the starch is carried along by the general action of the intestine. At first, excrementary matter has a very strong acid reaction, which, as Bischoff supposes, is owing to the presence of a great quantity of organic acids, especially butyric acid. Pettenkofer and Voit have found in the gases exhaled by animals consuming starchy food, chiefly hydrogen and carburetted hydrogen. These same gases are also found, in the intestine of the herbivora. The expulsion of the starch is probably due to the generation of these gases, which excites the peristaltic movement of the intestine. If the chyme were permitted to remain longer in the intestine, the starch would be completely transformed into sugar and entirely absorbed. The obstinate diarrhœas of infants are doubtless often occasioned by this same phenomenon.

Voit shows that there are many other agencies which may exert similar influence upon intestinal movement. His assistant, Dr. Hoffmann, has observed that when cellulose is added to human food, for instance to flesh-meat, such meat then gives a largely-increased proportion of excrementitious matter. Purgatives, or sudden refrigeration of the abdominal region, may have the same effect. Bread containing all the constitutents of wheat causes, according to Meyer's experiments, prompt evacuation, by reason of the indigestible cellulose it contains. It yields a widely disproportionate quantity of excreta, as has been demonstrated by Panuni in the case of dogs fed on bread, when,

though evacuation increased, the amount of urea was diminished. White wheaten bread gives least excreta. The proportion of water contained in this matter affords the means of judging how long it had remained in the intestine, and how far the process of extracting the nutritive properties had gone. The substance evacuated in small quantity after a meal of flesh-meat contains hardly any remains of meat and 50 per cent. of solid matter, while the excreta from bread-food, evacuated in greater quantity, with much of the bread not transformed, has only 23 per cent. solid matter.

It might be supposed that the yeast in the bread is the cause of this; but Meyer has shown that a ration of starch-pudding and unleavened bread gives residuum in equal proportion with leavened bread. He has also shown that bread, into the composition of which enter nutritive salts, according to the Horsford process, gives a residuum equal to that of common bread. The result, therefore, is not due to the absence of these salts from bread. Dr. Bischoff has shown, in the course of some experiments he made at the instance of Liebig, that the addition of extract of meat, with or without salt, to the bread given to a dog, does not affect the intestinal absorption, nor does it lessen the amount of excrementitious matter. The objection might perhaps be urged that, as the dog is purely carnivorous, experiments made on him will not warrant a universal conclusion. Therefore, Dr. Hoffmann made the same experiment with a man. The man was fed on potatoes, pulse, and bread, and there were then 116 parts of dry excreta; when extract of meat was added, there were still 109.

According to Haubner, the addition of a little peas to potatoes notably diminishes or even entirely dissipates the starch, which else is found in great quantity in the excreta of sheep. This result he attributes to the influence of the albumen in the peas. Dr. Bischoff gave a dog 800 parts of bread and 100 of meat. The amount of residuum was not lessened, nor the assimilation of the bread increased. Dr. Meyer found a dog, on 1,000 parts of bread, to give 70 of excreta; on 1,000 of bread and 100 of meat, 66 parts; and on 1,000 of bread and 300 of meat, 75 of solid residue. There is, then, no means of promoting the digestion of bread or potatoes, or other vegetable food, in the intestine whether of man or of dog, nor of preventing the loss of the starch.

From the persevering observations of Dr. Hoffmann, it follows that this imperfect digestion and this voluminous excretion are unavoidable—a fact which, on a vegetable diet, necessitates larger consumption, even though each of the elements were in itself capable of absorption. If a man consumes in a day 1,000 parts potatoes, 207 lentils, 40 bread and beer, he takes in 14.7 of nitrogen. Of the latter he gives out 7 by the kidneys, and 6.9 in 116 of dry excreta. The latter contain 24 per cent. of the dry food, and 47 per cent. of the nitrogen. But, when he takes in animal food, the same amount of azote and of

starch in its respiratory equivalent of fat, i. e., 390 parts meat and 126 fat, he eliminates daily only 28.3 parts solid matter, with 2.6 of nitrogen; while on the contrary, the liquid excretion holds 14.2 of nitrogen. Consequently, though the amount of albumen in the two cases was the same, still twice as much of it was absorbed by the intestine from the ration of meat as from that of vegetables. The 800 parts of meat yielded only 27 of dry residuum.

This difference in absorption makes the essential difference between vegetable and animal food. Consequently, we are not justified in saying that 2.4 of starch is the equivalent of one part fat. Further, 1 part fat and 2.4 albumen, both absorbed by the same organism, have not the same action on the transformation of albumen or the admission of oxygen. Great caution must therefore be observed, in treating of such equivalencies, even where the elements of nutrition are analogous, but come from diverse sources. Their mutually different behavior in digestion has not been always taken into account.

Dr. Hoffmann has studied this subject for the human economy, as regards various alimentary substances or nutritive elements. Bread, potatoes, rice, maize, etc., taken in any quantity whatsoever, can scarcely support the life of man or of carnivorous animals, communicating to them no bodily strength. Too large a proportion of their nutritive elements is eliminated in the excretion. Still, with the addition of a small quantity of albumen, whether animal or vegetable, they may suffice. They are poor in albuminates, but rich in starch. Even herbivorous animals often take in an excess of food, so as to get the requisite amount of albumen.

The same occurs with man, and therefore he will waste non-azotized material. The quality of the food he takes may be told from the excreta. It is Liebig who said that you might make out the boundary-lines of those countries where the coarse brown bread of Westphalia is used, from certain indications found along the hedge-rows. An Irish laborer, according to Buckle, consumes daily 9½ lbs. of potatoes, a weight too great for all the intestines to carry. These potatoes would contain of water 3,200 parts, dry albumen 70, and of non-nitrogenous substances 725. The latter quantity is far in excess of what is necessary to nourish a strong man; but there is a deficiency of albumen, to say nothing of the amount lost in the excreta. As a consequence, the body is capable of but little work, notwithstanding the great quantity of potatoes taken in, and it is but ill provided with the means of resisting disease, owing to the excess of water in the organs. The same is to be said of rice, which is poor in nitrogen. According to Salvator Thomassi, the farmers of the rice-fields in Italy, who enjoy liberal fare, reach an advanced age, while the day-laborers who live on rice succumb prematurely to diseases caused by exhaustion. In Western India, where rice is the chief food of the natives, they always add some element of food which is richer in azote. Those Italian laborers

who come into Germany to work upon the railways always eat cheese with their staple food, maize. Other populations derive all their nutriment from 800 parts of bread and 100 of meat, besides potatoes and herrings. All these facts are in full accord with the experiment made on the dog, which lost weight on 800 parts of bread, or on the same with extract of meat, and finally died in convulsions.

On this subject we have the valuable researches of William Stark, dating from 1789. He tried experiments upon himself as to the relative value of different kinds of food. For 42 consecutive days he lived on 556 to 849 parts of bread and 900 to 1,800 water per day. Meanwhile he lost 17 lbs. weight. Then he took 736 to 962 of bread, 113 to 226 sugar and 900 to 1,300 water, and in 28 days lost 3 lbs. But he gained with 849 bread, 1,800 milk and 1,300 water. Hence it will be seen that prison-fare of bread-and-water is justly to be regarded as a punishment. In fact, the sentence condemning a man to live four weeks on such fare is in Danish law equivalent to sentence of death, and in Denmark no case has ever occurred of a culprit surviving his punishment.

Of course, Prof. Voit is far from condemning the use of vegetable substances for food; but he insists upon it that they must be combined with proper nutritive elements in assimilable form, in order to keep the body vigorous. These vegetable substances are deficient in albumen, and nothing can supply it better than flesh-meat. It is also advisable to substitute, for a part of the mass of starchy material, animal or vegetable fat. It is not denied but that one may sustain life on purely vegetable fare. The only conclusion the author insists upon in this first portion of his essay is, that the alimentation of man is always best secured, as regards azotic and fatty food, when the latter is got from animal matter, and oftentimes the elements in question cannot be derived from any other source. Chemistry alone will not account for this disparity. The principles of which we speak do not differ from one another chemically in their origin. It is only physiological experimentation, with the living being as the reactive agent, that can show these differing properties, as we have seen. This is a point of great importance. The question of nutritive salts, which we are next to consider, is no less important.—*Revue Scientifique.*

MR. MARTINEAU ON EVOLUTION.

By HERBERT SPENCER.

THE propriety of dealing with the leading criticisms that have been made on the general doctrine set forth in "First Principles"—more especially criticisms on the metaphysical aspects of that doctrine—has been from time to time pressed upon me. Having recently been led to

undertake a subject outside of, though ancillary to, the work with which I am chiefly occupied, a contemplated reply to these criticisms has been put aside for a while. The article by Mr. Martineau, in the April number of the *Contemporary Review*, on "The Place of Mind in Nature, and Intuition in Man," while it reminded me of this postponed essay, because containing further criticisms to be met, did not lead to any change of intention. I learn, however, that Mr. Martineau's arguments, which, though not avowedly directed against propositions asserted or implied in "First Principles," tell against them by implication, are supposed by some to be conclusive, and that, in the absence of replies, it will be assumed that no replies can be made. It seems desirable, therefore, to notice these arguments at once—especially as the essential ones may, I think, be effectually dealt with in comparatively small space.

The first definite objection which Mr. Martineau raises is, that the hypothesis of general evolution is powerless to account even for the simpler orders of facts in the absence of numerous different substances. He argues that, were matter all of one kind, no such phenomena as chemical changes would be possible, and that, "in order to start the world on its chemical career, you must enlarge its capital, and present it with an outfit of *heterogeneous* constituents. Try, therefore, the effect of such a gift; fling into the preëxisting caldron the whole list of recognized elementary substances, and give leave to their affinities to work." The intended implication obviously is, that there must exist the separately-created elements before evolution can begin. Here, however, Mr. Martineau makes an assumption which few, if any, chemists will commit themselves to, and which many will distinctly deny. There are no "recognized elementary substances," if the expression means substances known to be elementary. What chemists, for convenience' sake, call elementary substances, are merely substances which they have thus far failed to decompose; but, bearing in mind past experiences, they do not dare to say that they are absolutely undecomposable. Water was taken to be an element for more than 2,000 years, and then was proved to be a compound; and, until Davy brought a galvanic current to bear upon them, the alkalies and the earths were supposed to be elements. So little true is it that the "recognized elementary substances" are supposed to be absolutely elementary, that there has been much speculation among chemists respecting the process of compounding and recompounding by which they have been formed out of some ultimate substance—some chemists having supposed the atom hydrogen to be the unit of composition, but others having contended that the atomic weights of so-called elements are not thus interpretable. If I remember rightly, Sir John Herschel was one, among others, who, some five-and-twenty years ago, threw out suggestions respecting the composition of them. What was at that time a suspicion has now become practically a certainty. Spectrum analysis yields results wholly irreconcilable with the assumption that the conventionally-named sim-

ple substances are really simple. Each yields a spectrum having lines varying in number from two to eighty—lines every one of which implies the intercepting of ethereal undulations of a certain order by something oscillating in unison or in harmony with them. Were iron absolutely elementary, it is not conceivable that its atom could intercept ethereal undulations of eighty different orders: though it does not follow that its molecule contains as many separate atoms as there are lines in its spectrum, it must clearly be a complex molecule. The evidence thus gained points to the conclusion that, out of some primordial unit, the so-called elements arise by compounding and recompounding; just as by the compounding and recompounding of elements there arise oxides, and acids, and salts. And this hypothesis is entirely in harmony with the phenomena of allotropy. Various so-called elementary substances have several forms under which they present quite different properties. The semitransparent, colorless, extremely active substance commonly called phosphorus may be so changed as to become opaque, dark red, and inert. Like changes are known to occur in some gaseous, non-metallic elements, as oxygen; and also in metallic elements, as antimony. These total changes of properties, brought about without any changes to be called chemical, are interpretable only as due to molecular arrangements; and, by showing that difference of property is produced by difference of arrangement, they support the inference otherwise to be drawn, that the properties of different elements result from differences of arrangement produced by the compounding and recompounding of ultimate homogeneous units. Thus Mr. Martineau's objection, which at best would imply a turning of our ignorance of the nature of elements into positive knowledge that they are simple, is, in fact, to be met by two sets of evidences, which distinctly imply that they are compound.

Mr. Martineau next alleges that a fatal difficulty is put in the way of the General Doctrine of Evolution by the existence of a chasm between the living and the not-living. He says: "But with all your enlargement of data, turn them as you will, at the end of every passage which they explore, the *door of life* is closed against them still." Here again our ignorance is employed to play the part of knowledge: the fact that we do not know distinctly how an alleged transition has taken place is transformed into the fact that no transition has taken place. We have over again the mode of argument which until lately was thought conclusive—because the genesis of each species of creature had not been explained, therefore each species must be specially created. Merely noting this, however, I go on to remark that scientific discovery is day by day narrowing the chasm, or, to use Mr. Martineau's metaphor, "opening the door." Not many years since, it was held as certain that the chemical compounds distinguished as organic could not be formed artificially. Now, more than a thousand organic compounds have been formed artificially. Chemists have discovered the art of

building them up, from the simpler to the more complex, and do not doubt that they will eventually produce the most complex. Moreover, the phenomena attending isomeric change give a clew to those movements which are the only indications we have of life in its lowest forms. In various colloidal substances, including the albuminoid, isomeric change is accompanied by contraction or expansion, and consequent motion; and, in such primordial types as the *Protogenes* of Haeckel, which do not differ in appearance from minute portions of albumen, the observed motions are comprehensible as accompanying isomeric changes caused by variations in surrounding physical actions. The probability of this interpretation will be seen on remembering the evidence we have that, in the higher organisms, the functions are essentially effected by isomeric changes from one to another of the multitudinous forms which protein assumes. Thus the reply to this objection is, first, that there is going on from both sides a rapid narrowing of the chasm supposed to be impassable; and, second, that, even were the chasm not in course of being filled up, we should no more be justified in therefore assuming a supernatural commencement of life than Kepler was justified in assuming that there were guiding-spirits to keep the planets in their orbits, because he did not see how else they were to be kept in their orbits.

The third definite objection made by Mr. Martineau is of kindred nature. The Hypothesis of Evolution is, he thinks, met by the insurmountable difficulty that plant-life and animal life are absolutely distinct. He says:

> "You cannot take a single step toward the deduction of sensation and thought: neither at the upper limit do the highest plants (the exogens) transcend themselves and overbalance into animal existence; nor at the lower, grope as you may among the sea-weeds and sponges, can you persuade the sporules of the one to develop into the other."

This is an extremely unfortunate objection to raise. For, though there are no transitions from vegetal to animal at the places Mr. Martineau names, where, indeed, no biologist would dream of looking for them, yet the connection between the two great kingdoms of living things is so complete that separation is now regarded as impossible. For a long time naturalists endeavored to frame definitions such as would, the one include all plants and exclude all animals, and the other include all animals and exclude all plants. But they have been so repeatedly foiled in the attempt that they have given it up. There is no chemical distinction that holds; there is no structural distinction that holds; there is no functional distinction that holds; there is no distinction as to mode of existence that holds. Large groups of the simpler animals contain chlorophyll, and decompose carbonic acid under the influence of light as plants do. Large groups of the simpler plants, as you may observe from the diatoms from any stagnant pool,

are as actively locomotive as the minute creatures classed as animals seen along with them; and among these lowest types of living things it is common for the life to be now predominantly animal and presently to become predominantly vegetal. The very name *zoospores*, given to germs of *algæ*, which for a while swim about actively by means of cilia, and presently settling down grow into plant-forms, is given because of this conspicuous community of nature. So complete is this community of nature that for some time past many naturalists have wished to establish for these lowest types a sub-kingdom intermediate between the animal and the vegetal: the reason against this course being, however, that the difficulty crops up afresh at any assumed places where this intermediate sub-kingdom may be supposed to join the other two. Thus the assumption on which Mr. Martineau proceeds is diametrically opposed to the conviction of naturalists in general.

Though I do not perceive that it is specifically stated, there appears to be tacitly implied a fourth difficulty of an allied kind—the difficulty that there is no possibility of transition from life of the simplest kind to mind. Mr. Martineau says, indeed, that there can be "with only vital resources, as in the vegetal world, no beginning of mind;" apparently leaving it to be inferred that in the animal world the resources are such as to make the "beginning of mind" comprehensible. Whether any consciousness of an incongruity between the conception of "germs of mind as well as the inferior elements," and his hypothesis of universal mind as the cause of evolution, prevented Mr. Martineau from pressing this objection, I do not know. But, had he asserted a chasm between mind and bodily life, for which there is certainly quite as much reason as for asserting a chasm between animal life and vegetal life, the difficulties in his way would have been no less insuperable. For those lowest forms of irritability in the animal kingdom, which, I suppose, Mr. Martineau refers to as the "beginning of mind," are not distinguishable from the irritability which plants display: they in no greater degree imply consciousness. If the sudden folding of a sensitive-plant's leaf when touched, or the spreading out of the stamens in a cistus-flower when you brush them, is to be considered as a vital action of a purely physical kind, then so too must be considered the equally slow retraction of a polype's tentacles. And yet, from this simple motion of an animal having no nervous system, we may pass by insensible stages through ever-complicating forms of actions, with their accompanying signs of feeling and intelligence, until we reach the highest. Even apart from the evidence derived from the ascending grades of animals up from *zoophytes*, as they are significantly named, it needs only to observe the evolution of a single animal to see how baseless is the assumption that there exists any break or chasm between the life that shows no mind and the life that shows mind. The yolk of an egg which the cook has just broken not only yields no sign of mind, but yields no sign of life. It does not re-

spond to a stimulus as much even as many plants do. Had the egg, instead of being broken by the cook, been left under the hen for a certain time, the yolk would have passed by infinitesimal gradations through a series of forms ending in the chick, and by similarly infinitesimal gradations would have arisen those functions which end in the chick breaking its shell; and which, when it gets out, show themselves in running about, distinguishing and picking up food, and squeaking if hurt. When did the feeling begin, and how did there come into existence that power of perception which the chick's actions show? Should it be objected that the chick's actions are mainly automatic, I will not dwell on the fact that, though they are largely so, the chick manifestly has feeling and therefore consciousness, but I will accept the objection, and propose that instead we take the human being. The course of development before birth is just of the same general kind; and similarly, at a certain stage, begins to be accompanied by reflex movements. At birth there is displayed an amount of mind certainly not greater than that of the chick—there is no power of running from danger, no power of distinguishing and picking up food. If we say the chick is unintelligent, we must certainly say the infant is unintelligent. And yet from the unintelligence of the infant to the intelligence of the adult, there is an advance by steps so small that on no day is the amount of mind shown appreciably different from that shown on preceding and succeeding days. Thus the tacit assumption, that there exists a break, is not simply gratuitous, but one that is negatived by the most obvious facts.

And now, having dealt with the essential objections raised by Mr. Martineau to the Hypothesis of Evolution as it is presented under that purely scientific form which generalizes the process of things, firstly as observed, and secondly as inferred from certain ultimate principles, let me go on to examine that form of the Hypothesis which he propounds—Evolution as determined by Mind and Will—Evolution as prearranged by a Divine Actor. For Mr. Martineau apparently abandons the primitive theory of creation by "fiat of Almighty Will" and also the theory of creation by manufacture—by "a contriving and adapting power," and seems to believe in Evolution; requiring only that "an originating mind" shall be taken as its antecedent. Let us ask, first, in what relation Mr. Martineau conceives the "originating mind" to stand to the evolving universe. From some passages it is inferable that he considers the "presence of mind" to be everywhere needful. He says:

"It is impossible to work the theory of Evolution upward from the bottom. If all force is to be conceived as one, its type must be looked for in the highest and all-comprehending term; and Mind must be conceived as there, and as divesting itself of some specialty at each step of its descent to a lower stratum of law, till represented at the base under the guise of simple Dynamics."

This seems to be an unmistakable assertion that, whenever evolution is going on, mind is then and there behind it. At the close of the argument, however, a quite different conception is implied. Mr. Martineau says:

"If the Divine Idea will not retire at the bidding of our speculative science, but retain its place, it is natural to ask, What is its relation to the series of so-called Forces in the world? But the question is too large and deep to be answered here. Let it suffice to say, that there need not be any overruling of these forces by the Will of God, so that the supernatural should disturb the natural; or any supplementing of them, so that He should fill up their deficiencies. Rather is His thought related to them as, in Man, the mental force is related to all below it."

It would take too much space to deal fully with the various questions which this passage raises. There is the question, Whence come these "Forces," spoken of as separate from the "Will of God"—did they preëxist? Then what becomes of the divine power? Do they exist by the divine Will? Then what kind of nature is that by which they act on the divine Will? Again, there is the question, how do these deputy-forces coöperate in each particular phenomenon, if the presiding Will is not there present to control them? Either an organ which develops into fitness for its function, develops by the coöperation of these forces only under the direction of Mind there present, or they do it in the absence of Mind? If they do it in the absence of Mind, the hypothesis is given up; and if the "originating mind" is required to be then and there present, it must be regarded as universally present. Once more there is the question, If "His thought" is related to them [these forces] as, in Man, the mental force is related to all below it, how can "His thought" be regarded as the cause of evolution? In man the mental force is related to the forces below it neither as a creator of them, nor as a regulator of them, save in a very limited way: the greater part of the forces present in man, both structural and functional, defy the mental force absolutely. Not dwelling on these questions, however, it will suffice to point out the entire incongruity of this conception with the previous conception which I have quoted. Assuming that, when the choice is pressed on him, Mr. Martineau will choose the first, which alone has any thing like defensibility, let us go on to ask how far Evolution is made comprehensible by postulating Mind, universally immanent, as its cause.

In metaphysical controversy, many of the propositions propounded and accepted as quite believable are absolutely inconceivable. There is a perpetual confusing of actual ideas with what are nothing but pseud-ideas. No distinction is made between propositions that contain real thoughts, and propositions that are only the forms of thoughts. A thinkable proposition is one of which the two terms can be brought together in consciousness under the relation said to exist between

them. But very often, when the subject of a proposition has been thought of as something known, and when the predicate has been thought of as something known, and when the relation alleged between them has been thought of as a known relation, it is supposed that the proposition itself has been thought. The thinking separately of the elements of a proposition is mistaken for the thinking of them in the combination which the proposition affirms. And hence it continually happens that propositions which cannot in truth be rendered into thought at all are supposed to be not only thought but believed. The proposition that Evolution is caused by Mind is one of this nature. The two terms are separately intelligible; but they can be regarded in the relation of effect and cause only so long as no attempt is made to put them together in the relation.

The only thing which any one knows as mind is the series of his own states of consciousness. The mind so known to each person, and inferred by each to be present in others, has the essential characters, that its components are limited by one another, and that it is itself localized both in time and space. If I am asked to frame a notion of mind, divested of all those structural traits under which alone I am conscious of mind in myself, I cannot do it. I know nothing of thought save as carried on in terms originally derived from the effects wrought by objects on me. A mental act is an unintelligible phrase if I am not to regard it as an act in which states of consciousness are severally assimilated to other states in the series that has gone by, and in which the relations between them are severally assimilated to past relations in this series. I cannot give any meaning to the word Will, unless I am to think of it in terms of contemplated ends, of which some one is preferred.

If, then, I have to conceive Evolution as caused by an "originating Mind," I must conceive this mind as having attributes akin to those of the only mind I know, and without which I cannot conceive mind at all. I will not dwell on the many incongruities hence resulting, by asking how the "originating Mind" is to be thought of as having states produced by things objective to it; as discriminating among these states, and classing them as like and unlike; and as preferring one objective result to another. I will simply ask, What happens if we ascribe to the "originating Mind" the character absolutely essential to the conception of mind, that it consists of a series of states of consciousness? Put a series of states of consciousness as cause, and the evolving universe as effect, and then endeavor to see the last as flowing from the first. It is possible to imagine in some dim kind of way a series of states of consciousness serving as antecedent to any one of the movements I see going on; for my own states of consciousness are often indirectly the antecedents to such movements. But how if I attempt to think of such a series as antecedent to all actions throughout the universe—to the motions of the multitudinous stars through space

to the revolutions of all their planets round them, to the gyrations of all these planets on their axes, to the infinitely-multiplied physical processes going on in each of these suns and planets? I cannot even think of a series of states of consciousness as causing the relatively small group of actions going on over the earth's surface; I cannot even think of it as antecedent to all the various winds and the dissolving clouds they bear, to the currents of all the rivers, and the guiding actions of all the glaciers; still less can I think of it as antecedent to the infinity of processes simultaneously going on in all the plants that cover the globe, from tropical palms down to polar lichens, and in all the animals that roam among them, and the insects that buzz about them. Even to a single small set of these multitudinous terrestrial changes, I cannot conceive as antecedent a series of states of consciousness—cannot, for instance, think of it as causing the hundred thousand breakers that are at this instant curling over the shores of England. How, then, is it possible for me to conceive an "originating Mind," which I must represent to myself as a series of states of consciousness, being antecedent to the infinity of changes simultaneously going on in worlds too numerous to count, dispersed throughout a space that baffles imagination? If, to account for this infinitude of physical changes everywhere going on, "Mind must be conceived as there under the guise of simple Dynamics," then the reply is that, to be conceived as there, Mind must be divested of all attributes by which it is distinguished; and that when thus divested of its distinguishing attributes, the conception disappears—the word Mind stands for a blank. If Mr. Martineau takes refuge in the entirely different and, as it seems to me, incongruous hypothesis of something like a plurality of minds—if he accepts, as he seems to do, the doctrine that you cannot explain Evolution "unless among your primordial elements you scatter already the *germs* of Mind as well as the inferior elements"—if the insuperable difficulties I have just pointed out are to be met by assuming a local series of states of consciousness for each phenomenon, then we are obviously carried back to something like the old fetichistic notion, with the difference only, that the assumed spiritual agencies are indefinitely multiplied. Clearly, therefore, the proposition that an "originating Mind" is the cause of Evolution is a proposition that can be entertained so long only as no attempt is made to unite in thought its two terms in the alleged relation. But when the attempt to unite them is made, the proposition turns out to be not simply unprovable, but unthinkable.

Here let me guard myself against a misinterpretation very likely to be put upon the foregoing arguments—especially by those who have read the Essay to which they reply. The statements of that Essay carry the implication that all who adhere to the hypothesis it combats imagine they have solved the mystery of things when they have explained the processes of Evolution as naturally caused. Mr. Martineau tacitly represents them as believing that, when every thing has

been interpreted in terms of Matter and Motion, nothing remains to be explained. This, however, is by no means the fact. The Doctrine of Evolution, under its purely scientific form, does not involve Materialism, though its opponents persistently represent it as doing so. Indeed, among adherents of it who are friends of mine, there are those who speak of the Materialism of Buchner and his school, with a contempt certainly not less than that felt by Mr. Martineau. To show how entirely anti-materialistic my own view is, I may, perhaps, without impropriety, quote passages which I have written elsewhere:

"Hence, though of the two it seems easier to translate so-called Matter into so-called Spirit, than to translate so-called Spirit into so-called Matter (which latter is, indeed, wholly impossible), yet no translation can carry us beyond our symbols." [1]

And again:

"See, then, our predicament. We can think of Matter only in terms of Mind. We can think of Mind only in terms of Matter. When we have pushed our explorations of the first to the uttermost limit, we are referred to the second for a final answer; and, when we have got the final answer of the second, we are referred back to the first for an interpretation of it. We find the value of x in terms of y; then we find the value of y in terms of x; and so on we may continue forever, without coming nearer to a solution. The antithesis of subject and object, never to be transcended while consciousness lasts, renders impossible all knowledge of that Ultimate Reality in which subject and object are united." [2]

It is thus, I think, manifest that the difference between Mr. Martineau's view and the view he opposes is by no means so wide as he makes it appear; and further, it seems to me that such difference as exists is, in truth, rather the reverse of that which his exposition implies. Briefly expressed, the difference is this, that, when he thinks there is no mystery, the doctrine he combats recognizes a mystery. Speaking for myself only, I may say that, agreeing entirely with Mr. Martineau in repudiating the materialistic interpretation as utterly futile, I differ from him simply in this, that while he says he has found another interpretation, I confess that I cannot find any interpretation; while he holds that he can understand the Power which is manifested in things, I feel obliged to admit, after many failures, that I cannot understand it. This contrast does not appear of the kind which his Essay tacitly implies. I fail to perceive humility in the belief that human thought is capable of comprehending that which is behind appearances; and I do not see how piety is especially exemplified in the assertion that the Universe contains no mode of existence higher in Nature than that which is present to us in consciousness. On the contrary, I think it quite a defensible proposition that humility is better shown by a confession of incompetence to grasp in thought the Cause

[1] "Principles of Psychology," second edition, vol. i., § 63. [2] Ibid., § 272.

of all things; and that the religious sentiment may find a higher sphere in the belief that the Ultimate Power is no more representable in terms of human consciousness than human consciousness is representable in terms of a plant's functions.

Other parts of Mr. Martineau's argument I pass over as being met by implication in the above replies. I will now add only that, should any further explanation be required, I must postpone it until I am free from present special engagements.

MUSICAL MICE.

By Rev. SAMUEL LOCKWOOD, Ph. D.

THE study of geographical range is of extreme interest as affecting the life, forms, and functions of animals. In this way has come about that convenient division of the Monkey order into two great sections—the Simiadæ, or Old-World monkeys—and the Cebidæ, or New-World monkeys. And this distinction is based on differences easy to be understood. The monkeys of the Old World have their nostrils so nearly terminal, and so near to each other, and their teeth in sort and number so much like those of man, as to give them traits more human-like than those of the New World. They have also cheek-pouches, but none of them have prehensile tails. The New-World monkeys have their nostrils wide, lateral, and sprawling; they have more teeth than man has; they have no cheek-pouches; and with many the tail is prehensile. But does this law of geographical distribution, whatever it may be, affect "mice, and such small deer?" It does. A very large order is that known as the Rodents, or Gnawers, well represented by the squirrels and rabbits. These animals are all characterized by two chisel-shaped teeth in the front of each jaw. The order contains several well-marked families, and some six hundred species. Of these families, one is known as the *Muridæ*, which embraces the rats and the mice, and their allies. Now, it is interesting to know that the Muridæ, namely, the true rats and mice, as well as the monkeys, naturally divide into two geographical groups: the one called the *Mures*, or Old-World rats; and the other known as the *Sigmadontes*, or New-World rats. Each of these divisions includes the true rats and mice, indigenous to the New and the Old World, respectively. And these distinctions are founded on a real difference in anatomical structure. Let it suffice to mention the most striking, that of the teeth. The Mures, or Old-World rats and mice, have comparatively "large, broad molars, and those of the upper jaw have three tubercles: the Sigmadontes, or New-World rats and mice, have narrow

molars, and those in the upper jaw have two tubercles." The word *sigmadont* means sigma-toothed, from a marking on the enamel, resembling the Greek letter *sigma*, which really would be like our own letter *S*, if the latter were made by uniting two angles, instead of two curves.

The writer has elsewhere expressed his belief that among the Rodents is a good deal of latent or undeveloped musical capacity. The squeal of the frightened rabbit is musical; while the whistle of the woodchuck enlivens its burrow with its homely, merry little sound.

That our little cosmopolite, the Old-World mouse, whom Linnæus, on account of its smallness among its fellows, named *Mus musculus*, has achieved some distinction in the musical line, almost everybody knows. Indeed, these musical house-mice are almost ceasing to be uncommon. Even his less graceful, big relative, the rat, has tried his hand at the pipes, and not wholly without success. And, among these little erratics, some have been known that might be called more comical than entertaining — certain eccentrics, known as hiccoughing-mice. But these and the above are all, wherever found, directly or indirectly, of the Old-World race. That any New-World species had done aught of this sort was to naturalists unknown. A late friend of ours had a domestic mouse—"a singer, that is," as the old man said —"not much, but it would whistle a little—chirrup, you know." Now, it happened that, one day, our friend caught two wood-mice, real natives—delicate, white-footed things, that looked too innocent to do any thing else than step mincingly around in their delicate white-satin slippers. So they were put into the cage with the singing-mouse. Whether, like some other folks, they had no appreciation of foreign airs, we have no means of answering; but alas! in spite of their silken ways, they at once set upon and murdered the little musical mouse.

These wood-mice are often called white-footed mice. They belong to a genus of the Sigmadontes, known as the *Hesperomys*, or Vesper-mice, and are indigenous to this our Western Continent. There is a number of species in the genus; but those best known are diminutive things, not so large as the house-mouse, their sides are yellowish-brown, the back considerably darker, the abdomen and feet almost snowy-white. Their home is the woods. With but little sympathy for man, they will occasionally intrude for a time into his dwelling, when, as I believe, the domestic mouse withdraws. My friend Philip J. Ryall, Esq., in the spring of 1871, when at his Florida home, near St. Augustine, was disturbed, at night, by what he supposed to be the chirping of birds in the chimney. The mystery was cleared up in an unexpected way. A very small mouse came up from a crevice in the hearth, and, with singular boldness, took position in the middle of the sitting-room floor. Here it sat up on its hind-feet, and looked around with the utmost confidence, all the time singing in a low, soft, yet really warbling style. This visit became a daily business, until it

paid the penalty of its temerity by being captured. About a month after, this prodigy was intrusted to the custody of the writer. Of course, it came introduced as a "singing house-mouse." What was our astonishment at recognizing, in the little stranger, a true Hesperomys, and no house-mouse at all! It was one of the wood-mice, and among the smallest of the species. It is a female, and fully grown, yet not so large as a domestic mouse. Every pains was taken to secure the comfort and well-being of my little guest.

And what an ample reward I reaped! For a considerable time she carolled almost incessantly, except when she slept. Day and night she rollicked in tiny song, her best performances being usually at night. To me it was often a strange delight, when, having wrought into the late hours, and the weary brain had become so needful and yet so repellant of sleep, I lay down, and gave myself up to listening to this wee songster, whose little cage I had set on a chair by my bedside. To be sure, it was a low, very low, sweet voice. But there was, with a singular weirdness, something so sweetly merry, that I would listen on, and on, until I would fall asleep in the lullaby of my wingless and quadrupedal bob-o'-link. The cage had a revolving cylinder or wheel, such as tame squirrels have. In this it would run for many minutes at a time, singing at its utmost strength. This revolving cage, although ample as regards room, was not over three and a half inches long, and two and a half inches wide. Although I have now been entertained by these pretty little melodies for a year, yet I would not dare redescribe them. In the *American Naturalist*, for December, 1871, the music is given with that elaboration which was possible under impressions so novel and delightful. She had two especially notable performances. I called these *rôles*—one the *wheel-song*, because it was usually sung while in the revolving cylinder, and the other the *grand rôle*. A remarkable fact in the latter is the scope of the little creature's musical powers. Her soft, clear voice falls an octave with all the precision possible; then, at its wind-up, it rises again into a very quick trill on C sharp and D.

I must quote from the above a paragraph entire. Let me simply premise that in our household this little creature goes by the pet name "Hespie."

"Though it be at the risk of taxing belief, yet I must in duty record one of Hespie's most remarkable performances. She was gambolling in the large compartment of her cage, in intense animal enjoyment. She had just woke from a long sleep, and had eaten of some favorite food, when she burst into a fulness of song very rich in its variety. While running and jumping, she carolled off, what I have called her *grand rôle;* then, sitting, she went over it again, ringing out the strangest diversity of changes, by an almost whimsical transposition of the bars of the melody; then, without, for even an instant, stopping the music, she leaped into the wheel, sent it revolving at its highest speed, and, while thus running in the wheel, she went through the wheel-song in exquisite style, giving

several repetitions of it. After this, without at all arresting the singing, she returned to the large compartment, sat upright, resumed again the *grand rôle*, and put into it some variations of execution which astonished me. One measure, I remember, was so silvery and soft that I said, to a lady who was listening, that a canary able to execute that would be worth a hundred dollars. I occasionally detected what I am utterly unable to explain—a literal dual sound (a rollicking chuckling), very like a boy, whistling as he runs, drawing a stick along the pickets of a fence. So the music went on, as I listened, watch in hand, until actually *nine minutes had elapsed!* Now, the wonderful fact is, that the rest between the *rôles* was never much more than for a second of time; and, during all this singing, the muscles could be seen in vigorous action, through the entire length of the abdomen. This feat would be impossible to a professional singer; and the nearest to it that I have heard was the singing of a wild mocking-bird in a grove."

The point which I think I have demonstrated elsewhere in this matter is, the invalidity of the position taken by some, that the singing faculty of these little creatures is due to a diseased condition. The specimen above dwelt on has been for a whole year at least in perfect health. It now appears, from a late number of the *Naturalist*, that a gentleman in Maryland amused himself in breeding white mice, in the hope of raising a singer. After raising several hundred, he procured one that manifested a little musical ability. It sang in six months about half a dozen times. He says that it is in perfect health, and that its offspring are the largest and the finest, and that it is an amiable, playful little pet. This was a domestic mouse, and at best but a very moderate singer. But Hespie differs in all respects. She is the wild wood-mouse, and an incessant singer, and one of very remarkable parts in musical ability. She has also many interesting differences pertaining to habits and food. Cheese is not relished by her; but insects and grass are choice morsels. Her greatest luxuries are worms, and maggots out of nuts and fruit. She will take an earthworm into her little hands, and, holding it up to her mouth at one end, will cause it to gradually shorten and disappear, as some bipeds from Faderland might dispatch a favorite sausage. Her agility in catching flies is wonderful; she leaps at the object, and rarely misses a catch.

A singular fact is this: she is subject to occasional attacks of nostalgia. They are brought about in this way: For her health, as well as for our comfort, the cage must be regularly cleansed. This is at all times annoying to her. But occasionally the little bed of cotton-wool, in a small box in her large compartment, is taken out, and burnt, and a new one is supplied. This occurs about once a month, and invariably this change of bed is followed by a day or two of homesickness. She is unhappy, seems not to like the situation, tears her bed up, pulls it out, then pulls it in, in part, and goes off somewhere, and lies down, a habit she does not like to indulge in outside of the privacy of her little box. The tiny being is undoubtedly sick, and has not much appetite. After at most two days, she becomes reconciled, and is as

merry and rollicking as ever, proving that to animals and men contentment is a continual feast.

She is not without imitation, for she has appeared to listen to, and to aim to imitate, the canary's song. Of course, imitations are seldom to be admired, and perhaps, even in music, mimicry may be set down as in the main base. I have known her to be excited into song by the playing of the piano, especially if the playing was in the natural key. There are many things that might be said, but the proverb on brevity is suggestive; so we will add only one thing more, and we regret that this last say is not in keeping with the Christian moral of speaking the last word kindly. Alas for little Hespie! She repels every gentle approach, even the hands that lovingly minister to her comforts; and, notwithstanding her great accomplishments, she is a capricious and unamiable little vixen.

THE STUDY OF HUMAN NATURE.

By Rev. H. W. BEECHER.

MY impression is, that preachers are quite as well acquainted with human nature as the average of well-informed citizens, but far less than lawyers, or merchants, or teachers, or, especially, politicians. I mean that, taking our American clergy generally, in their practical relations with society, while on the one hand they have shown themselves to be shrewd, discreet, and sagacious—and if their separate functions had lain in the conduct of affairs, socially, there would be but little to be criticised on the whole—yet, as *preachers*, they stand off toward the bottom of the list among students of human nature.

The school of the future (if I am a prophet, and I am, of course, satisfied in my own mind that I am!) is what may be called a *Life School*, with a style of preaching that is to proceed, not so much upon the theory of the sanctity of the Church and its ordinances, or upon a preëxisting system of truth which is in the Church somewhere or somehow, as upon the necessity for all teachers, first, to study the strengths and the weaknesses of human nature minutely; and then to make use of such portions of the truth as are required by the special needs of man, and for the development of the spiritual side of human nature over the animal or lower side—the preparation of man in his higher nature for a nobler existence hereafter. It is a life-school in this respect, that it deals not with the facts of the past, except in so far as they can be made food for the present and factors of the life that now is; but rather studies to understand *men*, and to deal with them face to face and heart to heart—yea, even to mould them as an artist moulds his clay or carves his statue. And, in regard to such a

school as that, while there has been a good deal done incidentally, the revised procedure of education yet awaits development and accomplishment; and I think that our profession is in danger, and in great danger, of going under, and of working effectively only among the relatively less informed and intelligent of the community; of being borne with, in a kind of contemptuous charity, or altogether neglected, by the men of culture who have been strongly developed on their moral side—not their moral side as connected with revealed religion, but as connected rather with human knowledge and worldly wisdom. The question, then, comes up, Do men need this intimately practical instruction; and, if so, must there be to meet it this life-school of preachers?

It is said, by some, "Has not Christianity been preached by plain men, who did not understand so very much about human nature, in every age of the world?" It has; and what has eighteen hundred years to show for it? To-day, three-fourths of the globe is heathen, or but semi-civilized. After eighteen hundred years of preaching of the faith under the inspiration of the living Spirit of God, how far has Christianity gone in the amelioration of the condition of the race? I think that one of the most humiliating things that can be contemplated, and one of the things most savory to the skeptical, and which seems the most likely to infuse a skeptical spirit into men, is to look at the pretensions of the men who boast of the progress of their work, and then to look at their performances. I concede that there has been a great deal done, and there has been a great deal of preparation for more; but I say that the torpors, the vast retrocessions, the long lethargic periods, and the wide degeneration of Christianity into a kind of ritualistic mummery and conventional usage, show very plainly that the past history of preaching Christianity is not to be our model. We must find a better mode of administration.

We need to study human nature, in the first place, because it is the Divine nature which we are to interpret to men. Divine attribute corresponds to our idea of human faculty. The terms are analogous. You cannot interpret the Divine nature except through some knowledge of human nature. There are those who believe that God transcends men, not simply in quality and magnitude, but in kind. Without undertaking to confirm or deny this, I say that the only part of the Divine nature that we can understand is that part which corresponds to ourselves, and that all which lies outside of what we can recognize is something that never can be interpreted by us. It is not within our reach. Whatever it may be, therefore, of God that, by searching we can find out, all that we interpret, and all that we can bring, in its moral influence, to bear upon men, is in its study but a higher form of mental philosophy.

Now, let us see what government is. It is the science of managing men. What is moral government? It is moral science, or the

theory upon which God manages men. What is the management of men, again, but a thing founded upon human nature? so that, to understand moral government, you are run right back to the same necessity. You must comprehend that on which God's moral government itself stands, which is human nature.

But, again, the fundamental doctrine on which our labors stand is the need of the transformation of man's nature by the Divine Spirit. This is altogether a question of pyschology. The old theological way of stating man's sinfulness, namely, "Total Depravity," was so gross and so undiscriminating, and was so full of endless misapprehensions, that it has largely dropped out of use. Men no longer are accustomed, I think, to use that term as once they did. That all men are sinful, is taught; but "What is meant by 'sinful?'" is the question which immediately comes back. Instantly, the schools begin to discuss it. Is it a state of the fibre of the substance or the soul? Is it any aberration, any excess, any disproportion of natural elements? Wherein does the fault lie? What is it? The moment you discuss this, you are discussing human nature. It is the mind you are discussing. In order to know what is an aberration, you must know what is normal. In order to know what is in excess, you must know what is the true measure. Who can tell whether a man is selfish, unless he knows what is benevolent? Who can tell whether a man has departed from the correct idea unless he has some conception of that idea? The very foundation on which you stand to-day necessitates knowledge of man as its chief basis.

Consider, too, how a minister, teaching the moral government of God, the nature of God, and the condition of man and his necessities, is obliged to approach the human soul. Men are sluggish, or are so occupied and filled with what are to them important interests, that, ordinarily, when a preacher comes into a community, he finds it either slumbering, or averse to his message, or indifferent to it; and, in either case, his business is to stimulate their moral nature. But how shall he know the art of stimulating man's moral nature, who has never studied it? You must arouse men and prepare them to be moulded. How can you do it, if you know nothing about them?

A man who would minister to a diseased body must have an accurate knowledge of the organs, and of the whole structure of the body, in a sanitary condition. We oblige our physicians to know anatomy and physiology. We oblige them to study morbid anatomy, as well as normal conditions. We say that no man is prepared to practise without this knowledge, and the law interferes, or does as far as it can, to compel it. Now, shall a man know how to administer to that which is a thousand times more subtle and important than the body, and which is the exquisite blossom of the highest development and perfection of the human system, namely, the mind in its modern development—shall a man assume to deal with that, and raise and

stimulate it, being ignorant of its nature? A man may know the Bible, from Genesis to Revelation; he may know every theological treatise from the day of Augustine to the day of Dr. Taylor; and, if he does not understand human nature, he is not fit to preach.

Suppose a man should undertake to cut off your leg because he had been a tool-maker? He had made lancets, probes, saws, and that sort of thing all his life; but he had never seen a man's leg amputated, and did not know exactly where the arteries or veins lie. Suppose he should think that making surgeons' tools fitted him to be a surgeon—would it? The surgeon must know his tools and how to handle them, but he must know, too, the system on which he is going to use them. And shall a man, charged with the care of the soul, sharpen up his understanding with moral distinctions and learned arguments, and know all about the theories of theology, from Adam down to our day, and yet know nothing of the organism upon which all these instrumentalities are to be used? Shall he know nothing about man himself? The student who goes out to his work with a wide knowledge of theology, and no knowledge of human nature, is not half fitted for his duty. One reason why so many succeed is, that, although they have no formal instruction in human nature, they have learned much in the family and in the school and by other indirect methods, and so have a certain stock—I might say an illegitimate stock—of knowledge, but which was not provided in the system of their studies.

If I might be allowed to criticise the general theological course, or to recommend any thing in relation to it, I should say that one of the prime constituents of the training should be a study of the human soul and body from beginning to end. We must arouse and stimulate men, and seek to bring them into new relations with truth, with ourselves, and with the community.

There is another consideration that we cannot blink, and that is, that we are in danger of having the intelligent part of society go past us. The study of human nature is not going to be left in the hands of the church or the ministry. It is going to be a part of every system of liberal education, and will be pursued on a scientific basis. There is being now applied among scientists a greater amount of real, searching, discriminating thought, tentative and experimental, to the whole structure and functions of man and the method of the development of mental force, than ever has been expended upon it in the whole history of the world put together. More men are studying it, and they are coming to results, and these results are starting, directly or indirectly, a certain kind of public thought and feeling. In religion, the psychological school of mental philosophers are not going to run in the old grooves of Christian doctrine. They are not going to hold the same generic ideas respecting men; and if ministers do not make their theological systems conform to facts as they are—if they do not recognize what men are studying, the time will not be far dis-

tant when the pulpit will be like the voice crying in the wilderness. And it will not be, "Prepare the way of the Lord," either. This work is going to be done. The providence of God is rolling forward a spirit of investigation that Christain ministers must meet and join. There is no class of people upon earth who can less afford to let truth run ahead of them than Christian ministers. You cannot wrap yourselves in professional mystery, for the glory of the Lord is such that it is preached with power throughout all the length and breadth of the world, by these investigators of His wondrous creation. You cannot go back and become an apostle of the dead past, drivelling after ceremonies, and letting the world do the thinking and studying. There must be a new spirit infused into the ministry. Some men are so afraid that, in breaking away from the old systems and original forms and usages, Christianity will get the go-by! Christianity is too vital, too really divine in its innermost self, to fear any such results. There is no trouble about Christianity. You take care of yourselves and of men, and learn the truth as God shows it to you all the time, and you need not be afraid of Christianity—that will take care of itself. You might as well be afraid that battles would rend the sky, or that something would stop the rising and setting of the sun. The power of Divine love and mercy is not going to be stopped, and will certainly not be stopped, by the things that are true.

You cannot afford to shut your eyes to the truths of human nature. Every Christian minister is bound to fairly look at these things. Every scientific man who is studying human nature is bound to open his eyes and ears, and to study all its phenomena. I read that Huxley refused to attend a *séance* of spiritualists. He said, contemptuously, that it was a waste of time, and gave expression to other sentiments of disdain. I am not an adherent of the spiritual doctrines; I have never seen my way clear to accept them. But phenomena which are wrapping up millions of men, and vitally affecting their condition, are not to be disdained by scientific men, whose business it is to study phenomenology of all kinds. No scientific man can excuse himself from examining them. He may say that he has no time to do it, and that some other man must investigate them. That would be right. All men cannot do all things. But to speak of any thing of this kind with contempt is not wise. I am not afraid to look at this thing, or any thing. I am not afraid that we are going to have the New Testament taken away from us. We must be more industrious in investigation, more honest in deduction, and more willing to take the truth in its new fulness; and we must be imbued with that simplicity in faith and truth which we inculcate in our people.

With this general statement of the necessity of the study of the human nature and mind in its structure and functions, I will pass on to the next point, which is, the way in which this study is to be prosecuted. How are we going about it?

In the first place, you must study facts, scientifically. I think that such works as Bain's, while criticisable in many directions, nevertheless are works of very great interest as showing a wise tendency in the investigation of the mind of man—the founding of mental philosophy upon physiology. I do not commend the system in all its particulars, but I speak of its tendency, which is in the right direction. I would say the same, also, of Herbert Spencer's works. There is much in him that I believe will be found sovereign and noble in the final account of truth, when our knowledge of it is rounded up. There was never a field of wheat that ripened which did not have a good deal of straw and husk with it. I doubt not but Herbert Spencer will have much straw and husk that will need to be burned. Nevertheless, the direction he is moving in is a wise one, which is the study of human nature—of the totality of man.

It was believed once that man did not think by the brain. I believe that notion has gone by. Most men now admit that the brain is the organ of the mind. It is held that it cannot be partitioned off into provinces, and that there are no external indications of its various functions. I shall not dispute that question with you. It is now generally conceded that there is an organization which we call the nervous system in the human body, to which belong the functions of emotion, intelligence, and sensation, and that that is connected intimately with the whole circulation of the blood, with the condition of the blood as affected by the liver, and by aëration in the lungs; that the manufacture of the blood is dependent upon the stomach: so a man is what he is, not in one part or another, but all over; one part is intimately connected with the other, from the animal stomach to the throbbing brain; and when a man thinks, he thinks the whole trunk through. Man's power comes from the generating forces that are in him, namely, the digestion of nutritious food into vitalized blood, made fine by oxygenation; an organization by which that blood has free course to flow and be glorified; a neck that will allow the blood to run up and down easily; a brain properly organized and balanced; the whole system so compounded as to have susceptibilities and recuperative force; immense energy to generate resources and facility to give them out—all these elements go to determine what a man's working power is. And shall a man undertake to study human nature, every thing depending upon his knowledge of it, and he not study the prime conditions under which human nature must exist?

I have often seen young ministers sit at the table, and even those of sixty years of age, eating out of all proportion, beyond the necessities of their systems; and I have seen, on the other hand, ministers who ate below the necessities of their systems, under a vague impression that sanctifying grace wrought better on an empty stomach than on a full one. It seems to me that all Divine grace and Divine instruments honor God's laws everywhere; and that the best condition for

grace in the mental system is that in which the human body is in a perfect state of health. That is a question which every man can best settle for himself. Some men under-sleep and some over-sleep; some eat too much, and some too little. Some men use stimulants who do not need them, while others avoid them who need them and would be better for their use. There is a vast amount of truth relative to the individual that is not studied by the minister, though it ought to be, as to the incoming and the outflow of force. Some clergymen prepare themselves to preach on Sunday by sitting up very late on Saturday night, and exhausting their vitality, thus compelling themselves to force their overtasked powers to extraordinary exertion to perform their Sabbath duties; which entails upon them the horrors of Blue Monday, the result of a spasmodic and drastic excitement. It is, and it ought to be, a purgatory to them. You must study yourselves as men. Is there no self-knowledge that can be acquired, so that a man shall know how to be merciful to his beast?

You see that whatever relates to the whole organization of the human body and its relations to health and to perfect symmetry must be studied, for all these relations are intimate, and concern both your own working powers and the material among men that you will have to work on.

In studying mental philosophy after this fashion, I would not have you ignore metaphysics. The perceptions of those subtle relations, near and remote, specific and generic, that obtain among spiritual facts of different kinds, I understand to be metaphysics; and that, I suppose, must be studied. I think it sharpens men and renders them familiar with the operations of the human mind, if not carried too far, and gives them a grasp and penetration that they would not get otherwise. It is favorable to moral insight, when developed in connection with the other sides of human nature. While I say that you ought to study mental philosophy with a strong physiological side to it, I do not wish it to be understood that I decry mental philosophy with a strong metaphysical side to it.

There is one question beyond that. While studying mental philosophy for the sake of religious education, and studying both sides of it, you are doing one thing; but when the question comes up *how* to study mental philosophy, I do not know any thing that can compare in facility of usableness with Phrenology. I do not suppose that phrenology is a perfect system of mental philosophy. It hits here and there. It needs revising, as in its present shape it is crude; but, nevertheless, when it becomes necessary to talk to people about themselves, I know of no other nomenclature which so nearly expresses what we need, and which is so facile in its use, as phrenology. Nothing can give you the formulated analysis of mind, as that can. Now let me say, particularly, a few things about this, and personally, too. I suppose I inherited from my father a tendency or intuition to read

man. The very aptitude that I recognize in myself for the exercise of this power would indicate a preexisting tendency. In my junior college year I became, during the visit of Spurzheim, enamoured of phrenology. For twenty years, although I have not made it a special study, it has been the foundation on which I have worked. Admit, if you please, it is not exactly the true thing; and admit, if you will, that there is little form or system in it; yet I have worked with it the same as botanists worked with the Linnæan system of botany, the classification of which is very convenient, although an artificial one. There is no natural system that seems to correspond to human nature so nearly as phrenology does.

For example, you assume that a man's brain is the general organ of the spiritual and intellectual functions.

I see a man with a small brow and big in the lower part of his head, like a bull, and I know that that man is not likely to be a saint. All the reasoning in the world would not convince me of the contrary, but I would say of such a man, that he has very intense ideas, and will bellow and push like a bull of Bashan. Now, practically, do you suppose I would commence to treat with such a man by flaunting a rag in his face? My first instinct in regard to him is what a man would have if he found himself in a field with a wild-bull, which would be to put himself on good manners, and use means of conciliation, if possible.

On the other hand, if I see a man whose forehead is very high and large, but who is thin in the back of the head, and with a small neck and trunk, I say to myself, "That is a man, probably, whose friends are always talking about how much there is in him, but who never does any thing. He is a man who has great organs, but nothing to drive them with. He is like a splendid locomotive without a boiler."

Again, you will see a man with a little bullet-head, having accomplished more than that big-headed man, who ought to have been a strong giant and a great genius. The bullet-headed man has outstripped the broad-browed man in every thing he undertook; and people say, "Where is your phrenology?" In reply, I say, "Look at that bullet-headed man, and see what he has to drive his bullet-head with!" His stomach gives evidence that he has natural forces to carry forward his purposes. Then look at the big-headed man. He can't make a spoonful of blood in twenty-four hours, and what he does make is poor and thin. Phrenology classifies the brain-regions well enough, but you must understand its relations to physiology, and the dependence of brain-work upon the quantity and quality of blood that the man's body makes.

You may ask, "What is the use of knowing these things?" All the use in the world. If a person comes to me, with dark, coarse hair, I know he is tough and enduring, and I know, if it is necessary, that I can hit him a rap to arouse him; but, if I see a person who has fine, silky hair, and a light complexion, I know that he is of an excitable

temperament, and must be dealt with soothingly. Again, if I see one with a large blue, watery eye, and its accompanying complexion, I say to myself that all Mount Sinai could not wake that man up. I have seen men of that stamp, whom you could no more stimulate to action, than you could a lump of dough by blowing a resurrection-trump over it.

Men are like open books, if looked at properly. Suppose I attempt to analyze a man's deeds; I can do it with comparative facility, because I have in my eye the general outline of the man's disposition and mental tendencies. A deed is like a letter stamped from a die. The motive that directs the deed is like the matrix that moulds the stamp. You may know the mould from the impression made by the stamp. You must know what men are in order to reach them, and that is a part of the science of preaching. If there is any profession in the world that can afford to be without this practical knowledge of human nature, it certainly is *not* the profession of a preacher. — *Abridged from the Christian Union.*

ASTRO-METEOROLOGY.

By Prof. DANIEL KIRKWOOD, LL. D.

THE theory that shooting-stars, meteoric stones, and even comets, consist of matter, which has been expelled with enormous force from the solar surface, was proposed by Prof. Hackley, as long since as 1860.[1] A similar hypothesis in regard to *comets* has also been advanced by Prof. William A. Norton.[2] In the present paper, it is proposed to consider, first, the evidence derived from recent discoveries in favor of this theory;[3] and, secondly, the indications afforded by observed phenomena in regard to the history of certain meteoric streams:

1. The observations of Zollner, Respighi, and others, have indicated the operation of stupendous eruptive forces beneath the solar surface. The rose-colored prominences, which Janssen and Lockyer have shown to be masses of incandescent hydrogen, are regarded by Prof. Respighi as phenomena of eruption. "They are the seat of movements of which no terrestrial phenomenon can afford any idea; masses of matter, the volume of which is many hundred times greater than that of the earth, completely changing their position and form

[1] Proc. Am. Assoc. for the Advancement of Science, Fourteenth Meeting, 1860.

[2] Treatise on Astronomy, fourth edition, Appendix, p. 437.

[3] The view that the fixed stars, as well as the sun, expel meteoric matter to the interstellar spaces, may be regarded as merely an extension of the theory here stated.

in the space of a few minutes." The nature of this eruptive force is not understood. If caused, as we may reasonably assume, by chemical combinations among the solar elements, it was probably in active operation long before the sun had contracted to its present dimensions.

2. With an initial velocity of projection equal to 380 miles per second, the matter thrown off from the sun would be carried beyond the limits of the solar system, never to return. With velocities somewhat less, it would be transported to distances corresponding to those of the aphelia of the periodic comets.

3. In the explosion witnessed by Prof. Young on the 7th of September, 1871,[1] the mean velocity between the altitudes of 100,000 and 200,000 miles was 166 miles per second. This indicates a velocity of about 200 miles per second at the lower elevation, and hence a considerably greater *initial* velocity. An equal force when the sun had but little more than twice its present diameter would have been sufficient to carry the projected matter beyond the orbit of Neptune.

4. This eruptive force, whatever be its nature, is probably common to the sun and the so-called fixed stars. If so, the dispersed fragments of ejected matter ought to be found in the spaces intervening between sidereal systems. Accordingly, the phenomena of comets and meteors have demonstrated the existence, in immense numbers, of extremely small cosmical bodies in the portions of space through which the solar system is moving. The origin of such masses, their collocations in groups, and their various physical characteristics, would seem to be satisfactorily accounted for by the theory under consideration.

5. According to Mr. Sorby,[2] the microscopic structure of the aërolites he has examined points evidently to the fact that they have been at one time in a state of fusion from intense heat—a fact in striking harmony with this theory of their origin.

6. The velocity with which some meteoric bodies have entered the atmosphere has been greater than that which would have been acquired by simply falling toward the sun from any distance, however great. On the theory of their sidereal origin, this excess of velocity has been dependent on the primitive force of expulsion.

7. A striking argument in favor of this theory may be derived from the researches of the late Prof. Graham, considered in connection with those of Dr. Huggins and other eminent spectroscopists. Prof. Graham found large quantities of hydrogen confined in the pores or cavities of certain meteoric masses. Now, the spectroscope has shown that the sun's rose-colored prominences consist of immense volumes of incandescent hydrogen; that the same element exists in great abundance in many of the fixed stars, and even in certain nebulæ; and that the star in the Northern Crown, whose sudden outburst

[1] *Boston Journal of Chemistry*, November, 1871.

[2] Proceedings of Royal Society, January, 1864.

in 1866 so astonished the scientific world, afforded decided indications of its presence.

Dr. Weiss, of Vienna, regards comets as the original bodies by whose disintegration meteor-streams are gradually formed.[1] In this respect his views differ somewhat from those of Schiaparelli.[2] "Cosmical clouds," he remarks, "undoubtedly appear in the universe, but only of such density that in most cases they possess sufficient coherence to withstand the destructive operation of the sun's attraction, not only up to the boundaries of our solar system, but even within it. Such cosmical clouds will always appear to us as comets when they pass near enough to the earth to become visible. Approaching the sun, the comet undergoes great physical changes, which finally affect the stability of its structure: it can no longer hold together: parts of it take independent orbits around the sun, having great resemblance to the orbit of the parent comet. With periodical comets, this process is repeated at each successive approach to the sun. Gradually the products of disintegration are distributed along the comet's orbit, and if the earth's orbit cuts this, the phenomenon of shooting-stars is produced."

The characteristics of the different meteor-streams afford interesting indications in regard to their relative age, the composition and magnitude of their corpuscles, etc. etc. Thus, if we compare the streams of August 10th and November 14th, we shall find that the latter probably entered our system at a comparatively recent epoch. We have seen that at each return to perihelion the meteoric cluster is extended over a greater arc of its orbit. Now, Tuttle's comet and the August meteors undoubtedly constituted a single cluster previous to their entering the solar domain. It is evident, however, from the annual return of the shower during the last 90 years, that the ring is at present nearly if not quite continuous. That the meteoric mass had completed many revolutions before the ninth century of our era is manifest from the frequent showers observed between the years 811 and 841. At the same time, the long interval of 83 years between the last observed display in the ninth century, and the first in the tenth, indicates the existence of a wide chasm in the ring no more than 1,000 years since.

The fact that the meteors of the November stream are diffused around only a small portion of their path, seems to justify the conclusion that the transformation of their orbit occurred at a date comparatively recent. Leverrier has calculated that the meteoric cloud passed very near Uranus about A. D. 126. He regards it, therefore, as highly probable that this was its first approach to the centre of our system.[3]

[1] *Astronomische Nachrichten*, Nos. 1710, 1711.

[2] For a condensed statement of Schiaparelli's theory, see an interesting article by Prof. Newton, in *Silliman's Journal* for May, 1867.

[3] *Comptes Rendus*, lxiv., p. 94.

It is proper to remark, however, that Newton's period of the meteors exceeds Oppolzer's period of the comet by twenty-seven days, and that each is liable to some uncertainty. But for the authority of the distinguished French astronomer, the writer would have fixed upon the year 43 B. C. as the probable epoch at which the cometary mass was thrown into its present orbit. Be this as it may, it undoubtedly suffered considerable perturbation about A. D. 126.

The question of the planetary disturbance of the meteor-streams is one of great interest. The November group has its perihelion at the orbit of the earth; its aphelion at that of Uranus. Both planets, therefore, at each encounter with the current not only appropriate a portion of the meteoric matter, but entirely change the orbits of a large number of meteors. In regard to the devastation produced by the earth in passing through the cluster, it is sufficient to state that, according to Weiss, the meteor orbits resulting from the disturbance will have all possible periods from 21 months to 390 years. It may be regarded, therefore, as an additional evidence of the recent introduction of this meteor-stream into the solar system that the comet of 1866, which constitutes a part of the cluster, has not been deflected from the meteoric orbit by either the earth or Uranus. It is, moreover, interesting to remark that the comet and Uranus will be in close proximity about the year 1983; perhaps so close as to throw the former into a new orbit.

As the comets 1862, III., and 1866, I., were doubtless more brilliant in ancient than in modern times, and as the former was conspicuously visible to the naked eye, it seems not improbable that they may have been formerly observed. The epochs of their ancient returns agree in several instances with those of comets of which the recorded observations are insufficient to determine their elements.

The writer as long since as 1861 suggested the probable disintegration of Biela's comet and the distribution of its matter around the orbit.[1] The earth crosses the path of these cometary fragments about the 29th or 30th of November—a well-known aërolitic epoch. It is also worthy of notice that an extraordinary number of shooting-stars was observed by M. Heis, at Aix-la-Chapelle, on the 29th of November, 1850.

From the fact that the earth, about the 20th of April, very nearly crosses the orbit of the comet 1861, I., a connection between the latter and the meteors of that epoch has been suggested by some astronomers. The period of the comet is, according to Oppolzer, 415 years. The first recorded shower of the April meteors occurred in the year 687 B. C.; the last great display in 1803 A. D. The interval is equal to six periods of 415 years. It is evident, however, that, if these meteors and the first comet of 1861 originally constituted a single group,

[1] *Danville Quarterly Review*, December, 1861. *See* also "Meteoric Astronomy," pp. 54, 55, 126–128.

they must have entered the solar system at a very remote epoch. The writer has elsewhere given reasons for regarding 28 years as nearly the true meteoric period.[1]

In its descending node, the orbit of Halley's comet is but 3,000,000 miles from that of the earth. Our planet passes this point of nearest approach a little before the middle of May. Is it not probable that some of the meteoric stones of May 8th to 14th[2] have been moving in nearly the same cometary orbit?

It has been pointed out by Dr. Weiss that the height at which the meteors of different rings appear and disappear depends, to some extent, on their respective velocities. The meteors of November 14th, for instance, move much more rapidly than those of August 10th, and are also observed at a greater altitude. Further observations of this interesting cluster can scarcely be expected till near the close of the present century.

IRON AND CIVILIZATION.[3]

By ABRAM S. HEWITT, Esq.

MR. PRESIDENT AND GENTLEMEN: To me is assigned the honor of bidding you welcome to the city of New York, on this, the occasion of our first annual meeting, and I am sure that you will find yourselves made welcome by all who have the honor and prosperity of the city at heart. For New York, although far from being the cherished home of science and art, comprehends that its growth and its future greatness depend upon the development of the natural resources of the country of which it is the commercial metropolis; and it is sufficiently enlightened to understand the necessity of scientific knowledge and trained experience for the attainment of the most useful and profitable results from industrial enterprises. No body of men can understand better than you that capital is essential to the development of natural resources on the scale demanded by modern civilization; but capital does not always comprehend as fully that science and experience are essential for the profitable use of money in the vast industrial undertakings of our day, and hence result great waste of resources and disastrous failures. A few considerations may serve to shed some light on this subject, of such material consequence to science and capital; and, at the risk of overstepping the conventional limits of a formal welcome, I venture briefly to suggest them as the means of establishing a common ground of sympathy and fellowship

[1] Proceedings of American Philosophical Society, March 4, 1870.

[2] "Meteoric Astronomy," p. 72.

[3] An address before the American Institute of Mining Engineers.

between the men of science and the men of business, and I am sure that you will pardon me if I draw my illustrations from that subject with which I am most familiar—the production of iron.

In 1856 I had occasion to trace the history of the manufacture of iron, and established what may be termed its law of development, rather rude indeed, but plainly dependent upon the growth of population and the spread of civilization throughout the world. At that time the annual production of iron had reached about 7,000,000 tons, of which Great Britain produced 3,500,000 tons, and the United States about 1,000,000 tons. The consumption of Great Britain was 144 pounds, and of the United States 84 pounds, while the average consumption of the world was only 17 pounds, per head, of population. It was shown that the consumption per head was steadily on the increase, and that consequently the annual production was enlarging so rapidly as to double once in 14 years; and it was predicted, after making due allowances for all the drawbacks, such as the wars which have unhappily taken place in the interval, beyond any possible expectation, that in 1875 the production of iron would surely reach 14,000,000 tons. The actual returns show that in 1871 the production amounted to 13,500,000 tuns, and in 1872 the limit 14,000,000 will undoubtedly be passed, so that the estimate made in 1856 is more than realized. Meanwhile the consumption has risen in England to 200 pounds, in the United States to 150 pounds, and in the whole world to 30 pounds, per head. It is not possible to convey a more striking idea of the progress of the world, during the last 17 years, than this statement affords. The consumption of iron measures the progress of civilization, and it is impossible not to believe that the whole world will ultimately require as much iron per head as we now use in the United States, when a total annual production of over 70,000,000 tons will be required. But, if these figures seem to be at all wild, no one can for a moment doubt that the next 17 years will double the present annual production of iron, bringing it up to 28,000,000 tons per annum; and I feel quite safe in asserting that the beginning of the twentieth century, which some among you may hope to see, will witness an annual production of over 40,000,000 tons.

You need not be told that iron is produced at less money-cost in Great Britain than in any other quarter of the globe. This has enabled her to produce about one-half of the total annual make. Of the 7,000,000 tons made in 1855, Great Britain produced 3,585,906 tons, and, of the 13,500,000 tons produced last year, she turned out nearly 7,000,000 tons. It it is evident, however, that there are limits in the way of raw material and labor beyond which Great Britain cannot go. While I see no reason to doubt that there will be a steady increase in production, it is evident that she will not be able to supply hereafter, as heretofore, so much as half the annual wants of the world for iron. But, allowing this proportion to Great Britain, there will still remain

14,000,000 tons to be made by the rest of the world. The history of the trade, as well as the natural resources of the several nationalities, prove that the bulk of this additional product can only be made in the United States. We are, in fact, the only people who have kept pace with Great Britain in the ratio of increase. In 1855, when Great Britain produced 3,500,000 tons, we produced 1,000,000 tons. In 1872, when Great Britain will produce 7,000,000 we produce 2,000,000 tons —the quantity produced in Great Britian in 1847, showing that we are only 25 years in arrear of her magnificent production. At the same rate, therefore, we could make 7,000,000 tons in 1897. But, as Great Britain cannot possibly maintain her rate of increase, there does not seem room for a doubt that our annual production will reach at least 10,000,000 and will probably amount to 15,000,000 tons before the close of the present century. This means that 25,000,000 to 40,000,000, tons of iron ore shall be annually extracted from our mines, and that our coal-production will exceed 100,000,000 tons per annum, required for iron and other branches of industry. It means that an investment of capital to the amount of $500,000,000 at least, and probably $1,000,000,000, shall be made in opening mines, erecting works, and supplying the requisite machinery of production. New York is already the financial centre of the American Continent, and is destined to be the main distributor of capital for the world. This vast sum of money will therefore be drawn from the accumulations of capital controlled in New York, and its productive results will depend mainly upon the judgment and skill displayed in its expenditure. Here, then, is the common ground on which Capital and Science must meet and shake hands, and be henceforth inseparable friends. But, if it be the mission of science thus to reconcile capital with industry, it is the still higher and nobler mission of science to reconcile industry with capital. The world is full of the conflict between capital and labor. Where there should be peace, there is war. Where Nature intended an absolute harmony, there is utter discord. For one, I am free to say, after the most careful investigation, and very extensive observation, that iron has heretofore been made at too low a cost in foreign countries to allow the workmen engaged in its production a fair share of the necessaries and comforts of life. This is due to the fact that the possession of virgin resources in coal and iron made it easy to increase production beyond the present wants of society. The resulting competition has had the effect to reduce prices to so low a point that proper wages could not be paid, and mankind has been enabled to get cheap goods at the expense of humanity itself.

I thank God, reverently and with gratitude unspeakable, that this day has passed, I trust, forever. These virgin resources are mainly exhausted, and it is no longer possible in Europe, at least, to produce more iron than the world requires; prices have risen; the workmen are demanding and receiving a more reasonable reward for their labor,

and it now only remains for them to fit themselves and their families for a rational use and enjoyment of the fruits of their toil. In looking back over the sad and gloomy fields of suffering among the European mines and works which I have traversed so often, and in looking forward to the more cheerful prospect now spread out before the sons of toil, I am tempted to exclaim with the patriarch: "Lord, now lettest Thou Thy servant depart in peace, for mine eyes have seen Thy salvation."

But cheap iron is a blessing to mankind, and to deprive the world of it is a calamity so serious that no one can contemplate it without a feeling of reluctance. Here, again, science steps in to reconcile high wages with cheap iron. It is the mission of science to cheapen processes, which enables wages to be raised without enhancing the cost of the product of the world. The history of industry is full of examples of the truth of this proposition, but for our purpose the Bessemer process affords its best illustration. By the genius of one man the whole world is enriched, its comforts enlarged, its progress promoted, and new fields of art and industry opened to its enterprise and energy. The annual saving in carrying on the business and transportation of the world can only be measured by millions; and when equal genius is applied to the proper distribution of the savings produced by the Bessemer process, by the Danks puddler, and other economical processes that have been and will be invented, the laboring classes all over the world will be lifted out of the depths, and this earth become the paradise it was intended to be, when the Great Giver of all endowed it with so much beauty and such boundless sources of wealth, and made the forces of Nature to be the servants of man, whenever he learns how to use and govern them. You, gentlemen, have limited yourselves to the study of physical laws and their application to industry, but I hope to see the day when all over this land, and throughout the world, there will be similar associations devoting themselves with equal zeal and intelligence to the discovery of the laws upon which society should be organized, and to the application of these laws to the proper distribution of the fruits of industry among those who labor for their production; so that nowhere in the world, and least of all in this land of boundless resources, shall it be said that there are idle hands because there is no work to be done, or that there are want and misery because there is not a just division of the proceeds of industry. If then, my views in regard to the dignity and importance of your mission be correct, you have not associated yourselves together one day too soon. You can derive encouragement from the magnificent results already achieved by your sister association, the British Iron and Steel Institute, only two years your senior, which has already given to the world several volumes of papers of inestimable value, and among them that admirable treatise of J. Lowthian Bell, on "the Chemical Phenomena of Iron Smelting," wherein the laws covering the operation of

the blast-furnace are placed upon settled foundations, and two continents have been made his debtor—a debt which you will gladly join with me in recognizing on the first suitable public occasion which has occurred since the completion of his great work.

Having thus briefly traced out the mission of science in our day to bring capital into productive relations with labor, and to remove the just grievances of labor, not against capital, but against its ignorant administration, and to make commodities cheap for the benefit and not at the expense of humanity, let me, in conclusion, sketch the picture which will be presented at the beginning of the next century, when our mining interests will be developed on a scale somewhat commensurate with the area of the country and the extent of its resources. As New York will be the centre of capital, so will it be the initial point of our iron and steel industry. On the shores of the Hudson River, the ores of Lake Champlain, of the valleys of Connecticut, and of the highland ranges of New York and New Jersey, will meet the anthracite coals of Pennsylvania upon conditions so favorable that New York and its vicinity must become a great metallurgical centre. Thence the chain of fire, extending across New Jersey and following the banks of the Lehigh and Schuylkill to the Susquehanna, will lead us by the margin of the coal-fields, along the outcrop of the magnetic, hematite, and fossiliferous ores which extend through Pennsylvania, Maryland, Virginia, North and South Carolina, Tennessee, Georgia, and Alabama, nearly to the Gulf, so that the light of furnace answering to furnace will never be lost sight of in the long line of over 1,000 miles! Hence, turning to the West, Missouri, Kentucky, Western Tennessee, Ohio, Indiana, and Illinois, will be all aglow with furnaces, forges, and mills, fed by the admirable fuel of the inexhaustible coal-fields of the West, and the superb ores of Missouri and Lake Superior. The waters of the great lakes will reflect the flames which will light up their margin, while to the west, along the lines of the various Pacific Railways, the newly-found coal and iron of that hitherto trackless region will form an enduring basis for the growth of industrious communities, busy cities, and teeming farms. The West coast will not be behind in the race, but an iron industry, more valuable than its mines of gold and silver, will yet supply its growing millions with the fundamental basis upon which modern civilization rests. The growth of this vast industry will be accompanied by the school-master, the preacher, and the physician. Homes of which human nature may be proud will be established in its wake, labor and Christianity will march hand in hand, binding all interests and all classes so harmoniously and so indissolubly together, that peace and good-will between capital and labor shall prevail throughout the land forever.

NERVOUS CONTROL OF ANIMAL MOVEMENTS.

FROM THE FRENCH OF M. ONIMUS.[1]

SINCE the celebrated experiments of Flourens, we know for certain that all the acts of the vegetative life in animals are completely independent of the cerebral lobes, and that an animal deprived of these continues to live as well as before, with only this difference, that it loses all will and instinct. With superior as well as inferior animals the cutting away of the cerebral lobes does not put an end to the movements which were possible before; only these movements take on particular characters. In the first place, they are more regular, and may be regarded as the true normal type, for mental influences do not modify them. The locomotive apparatus acts without restraint, and we may, therefore, say that the movements are more normal than in the normal state. In the second place, when the cerebrum is removed the movements only commence after excitations; they cannot start themselves. The frog must be put in the water to swim, and the pigeon thrown in the air to fly. In animals without a cerebrum the physiologist can determine such or such an act, limit it, arrest it; he can foresee movements, and tell in advance what will take place in such conditions, as absolutely as the chemist knows in advance the reactions he will get on mixing certain bodies.

Another peculiarity of movements that take place when the cerebral lobes are removed is, their continuation when once commenced. On the earth a frog without a cerebrum, when irritated, makes two, three, or more leaps; he rarely stops with one. Placed in the water he continues to swim till he encounters an obstacle. The pigeon continues to fly, the duck and the goose to swim. The striking thing about it is, the continuation of the state determined at first by an impulse from without; and we cannot help associating these facts, about animals deprived of their cerebral lobes, with the characteristic properties of inorganic matter. Put agoing, the animal without a cerebrum continues to move till the exhaustion of the conditions of movement, or till it encounters resistance. Put in repose, it remains inert till some exterior cause sets it in motion. It is inert living matter.

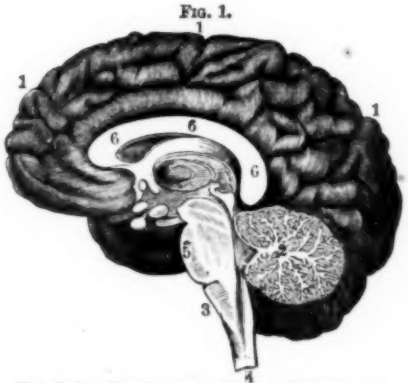
The phenomena we are about to consider are caused either by im-

[1] The importance of understanding the springs of animal movement and the conditions of their control is the reason for including the present article in THE POPULAR SCIENCE MONTHLY. It has been translated and abridged, from the *Revue Scientifique*, for the general reader, but those who wish for more detail in the presentation are referred to Dr. Hammond's *Quarterly Journal of Psychological Medicine*, for July, where the discussion will be given complete, and where kindred questions are elaborately discussed. Fig. 1 has been inserted to give a general notion of the parts of the brain referred to in the article.—ED.

pressions from without (excito-motor stimulation), or excitements from the sensorial centres (sensori-motor stimulation). In the frog, for example, the contact of the body with the earth makes him take his normal attitude, and when it is put in the water, says Vulpian, "the liquid produces a particular stimulation of all the surface of the body in contact with it; this stimulus calls into play the mechanism of swimming, and this mechanism ceases to move when the stimulus is withdrawn by taking the frog from the water."

The explanation of Vulpian is exact only within certain limits, for the frog remains motionless in the water when it encounters an obstacle, even when the stimulus of the water on its body is kept up; and, on the other hand, the surface of the pigeon's body is stimulated in the same way by the air, whether the wings are open or shut, and yet it is obliged to fly when it loses its point of support. There are,

FIG. 1.



THE RIGHT HALF OF THE HUMAN ENCEPHALON.

Encephalon is the term applied to the entire nervous mass within the head—the brain with all its parts. 1, 1, 1, *cerebrum*, cerebral lobes, or hemispheres. In man, this part is large; in lower animals, much smaller; in the lowest, it is extremely small, or rudimentary. 2, *cerebellum*, or lesser brain, connected with the other parts by fibres called *peduncles;* 3, *medulla oblongata*, or bulb, which is continuous downward, as (4) the *spinal cord;* 5, the *pons Varolii* (bridge of Varoli), a mass of cross-fibres which connect the two lobes of the cerebellum; 6, 6, 6, represent the *great commissure*, a body of cross-fibres which connects the two hemispheres and unifies the action of the brain. The lower portion of the brain consists of ganglia or centres of influence, connected with sensation, motion, and the vital processes. In man, these parts are relatively small, and are all covered in by the hemispheres; in inferior animals, like fishes and reptiles, they form the chief portion of the brain. The reader will remember, in the following experiments, that the nervous fibres, going from the head to the body, *decussate* or cross each other at the medulla oblongata, so that the right side of the encephalon is in relation with the left side of the body, while the right side of the body is controlled by the left side of the brain.

then, other causes of stimulation besides the impression upon cutaneous nerves. These are—first, the combination or solidarity of the movements which exist among animals deprived of the cerebral lobes; and, second, the necessity of maintaining an equilibrium.

What do we mean by solidarity of movement? When a brainless frog is swimming, and we apply a solid body to one of his fore-feet, immediately the corresponding hind-foot bends and touches the body in contact with the fore-foot. It is the same if we stop the motion of the fore-foot. Reciprocally, if the frog is motionless on the surface of

the water, and if we set the fore-foot in motion the hind-foot immediately begins to move, and the animal swims. In a word, to speak generally, when an animal is deprived of its cerebral lobes, if one limb begins to move the others immediately follow; if one comes to rest, the others tend to cease moving. Very seldom in these animals is the movement limited to a single member. This solidarity in the movements distinguishes animals deprived of the cerebral lobes, not only from animals with a brain, but also from those in which the spinal cord is severed at top.

In a frog with the cord cut near the cranial bulb, if we move a member, it produces no effect on the movements of the animal. If we excite one foot, only the subjacent muscles contract. If the impulse is stronger, the entire foot recedes, but the rest of the body is motionless. A lively excitation is needed to put the other feet in motion. In a word, each excitation, according to its energy, produces more or less extensive movement which may be limited to a single group of muscles. It is not so with a frog in which the spinal cord is unsevered; the movements which succeed a stimulus, whether it be strong or feeble, are always movements of the whole body.

If we put a drop of vinegar on the foot of a frog in which the cord is separated from the brain, the foot retires at first, then the other foot makes coördinated movements to get rid of the cause of irritation. The frog which has lost only its cerebral lobes commences, on the contrary, to make many leaps; afterward it moves only one or other of its feet. In the frog where the cord is severed, to each excitation succeed muscular contractions; these are always in proportion to the energy of the excitation. In the frog with the cord joined to the cerebellum alone, the excitation can take place without producing movement; but, be it feeble or strong, from the moment reflex action begins the result is the same—a movement of the body which produces a leap.

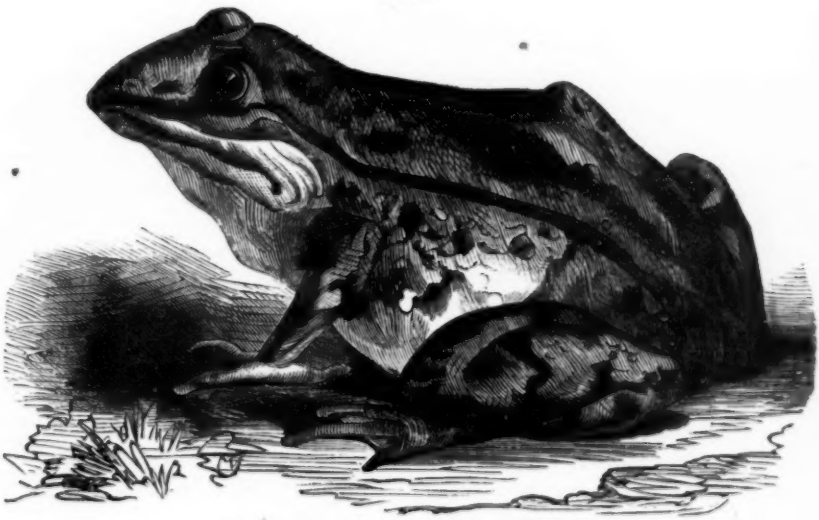
According to the excitation, to the kind of impression produced on the sensitive nerves of the skin, and on the nerves of muscular sense, there is formed among the different regions of the nervous centres a common purpose, which has for its regulator the *pons Varolii* (bridge of Varoli) and the cerebellum.

Another interesting effect now claims our notice. Among animals deprived of the cerebral lobes there is another curious and constant phenomenon, the forced and continual tendency to maintain an equilibrium. We have seen in the frog, the carp, the eel, the pigeon, the goose, mammals, etc., that every time we disturbed their centre of gravity, immediately there took place a series of coördinated movements which have the single aim of restoring the equilibrium. A decapitated insect remains always firmly posed on his feet and can take no other position. If a frog is motionless on a piece of board, and you slowly lower the board in the water so that he is immersed, in most

cases, notwithstanding the stimulus of the water on the integuments, the frog will remain immovable. If, now, you slowly withdraw the board below the frog without disturbing his position, he will remain motionless; but, if you tip it one side, the frog at once wakes from his quietude. The loss of equilibrium acts more energetically than the stimulus of the water on the skin.

Tip a carp to the right or left, at once it recovers its normal attitude. If you place a duck on one of its sides, either on the ground or in the water, it at once corrects itself and comes upright. The cerebellum alone controls equilibrium, as is easily proved by experiment. When it is wounded or destroyed, the animals lie indifferently on one side or the other, and make no movements to recover the lost equilibrium. In certain cases, even, they cannot maintain an equilibrium, but tend to fall on one side.

FIG. 2.



A Frog in which the Cerebrum has been removed.

We may conclude that the movements of animals, whether superior or inferior, are produced by certain special mechanisms, or by locomotive centres, situated at the base of the brain. These centres are essentially passive; they have no spontaneous action, and come into activity only when excited by peripheral stimulus or by the brain.

We ought, then, no longer to admit, in the habitual movements which appear perfectly voluntary, a direct action of the brain on each muscle. We must remember that there exist at the base of the brain motor centres which serve to intermediate between the will and external acts. The will calls into action such or such centres, and these immediately determine the action of certain muscular groups. We know besides, that,

according to the habits and education of the muscles, particular muscles can enter only with great difficulty upon isolated movements, and that the contraction of one muscle sometimes forces the contraction of others, even against the will.

There are, then, among the encephalic centres at the base of the brain, centres of coördination and direction of movement, which, so to speak, preside over the details of external acts (walking, swimming, flying, etc.), and which receive from the cerebrum only general orders to execute such or such bodily movements.

The motions of the body produced by the locomotive centres, under the influence of the brain, are of two orders: those of instinct or heredity, and those of habit. Both are inevitable, but they differ in this, that the first take place in all animals, whether young or old; while the second occur only in the old. To employ the usual expression, one is *nature;* the other, *second nature.* If you remove the cerebral lobes of a duck that has never been in the water, and then place it in water, it will swim regularly; but it will not, like an old duck deprived of its cerebrum, make certain habitual movements of the neck. The old pigeon, although without its cerebrum, when asleep places the head under the wing; and he often even dresses his feathers. Young pigeons have never been observed to perform these acts, while they execute other movements normally like old pigeons; their flight is very regular, even when they undergo the operation before leaving the nest.

It is, then, probable that by habit there are formed in the nervous centres certain connections between cellular groups, which give rise to bodily movements that become as imperative as those which are due to instinct.

In animals deprived of the cerebrum, then, the locomotive centres are still complete, and, as we have already said, they differ from the unmutilated only by the impossibility of spontaneously beginning movement. To act, they must receive an impulse either from without or within. Exterior excitement we can produce artificially, by acting on the peripheral nerves; interior excitation is produced by the cerebrum, and we may say that, from the point of view of physiology, the cerebrum has no other function than to put in action the different motor centres. It is a simple excitant, with this important difference—that external impressions can determine only a certain number of movements, while the brain provokes an immense variety.

Let us now consider the movements of rotation, which follow from wounds of portions of the encephalon. They are of two distinct types: the one is a rotary movement round a circle, the other a motion of rolling or spinning. In the first case, the animal remains in his normal attitude, but tends always to go to one side, and describe an orbit more or less extended. In the second case, the animal can progress but little in moving himself. When he attempts to move, he is forced

into a revolving motion, and turns on himself like a ball. The former movements are chiefly produced by lesions of the encephalon, and were obtained very neatly in a frog from which were removed the cerebral lobes of the left side. The movements were made from the left side toward the right.

What fixed attention at first in the attitude of this frog was, that all the right part of the body had the carriage and aspect of a frog without a cerebrum (Fig. 2). The hind-foot of this side approached the body more, and was gathered in a heap, as shown in Fig. 3, while the fore-foot was equally drawn up, and had the position that we have

Fig. 3.

A Frog that has lost the Left Half of the Cerebrum.

seen to be constant in frogs in which the cerebrum had been removed.

At the same time, the entire animal leaned a little to the right side. This inclination of the body is neither constant nor inevitable with animals which have only the movements in a circle; it is, on the contrary, constant and forced with those that have the turning motion.

The attitude of this frog changed, and was even reversed, when it

was chloroformed; the left side, which was more drawn up, where the muscles experienced a tonic contraction predominating over those of the right side, became then more feeble. This effect became more and more pronounced in proportion as the chloroform took effect, up to the time when the two sides were completely affected; then the frog would no longer rest on his fore-feet, and the hind-feet remained extended and motionless. In proportion as the anæsthesia disappeared, the feet of the healthy side folded themselves and approached the body; those of the opposite side remained still extended. Then these folded themselves similarly. The attitude of the two sides was then identical, but, when the normal state was recovered, the limbs on the side affected by the cerebral lesion again became more drawn up, and the body leaned on that side.

In this frog we have again on one side the influence of the cerebral lobes, but, on the other side, the locomotive centres are completely independent, and they act alone on the movements which take place on the corresponding side of the body. What happens, then, when the animal attempts to move? From the healthy side the movements are made according to the desire and the will, they are limited to the end wished by the animal; but, on the other side, they are made *en masse*, automatically, invariably; they drag the animal from their side; at the same time, the mathematical regularity of their contractions becomes, so to say, a dynamic centre for the movements of the opposite side, which are less regular. In this way we explain the movement in a circle, the side in relation with the wounded part being in the interior of the circle made by the animal. This also is the reason why such movements, particularly when the circumference is small, occur only when the animal can change his place, and very often commence only after the first moments of locomotion.

In case the cerebral influence is abolished, the locomotive centres become absolutely independent, as is shown by the forced automatic movements. Again these centres may be excited by a tumor, or a prick, and then their dependence upon the cerebral lobes ceases at once, notwithstanding the anatomical communications which still exist. It is in these cases that the compulsion, from the instant of the lesion, becomes invincible, and forces the animal into movement. The locomotive centres become active, and, as long as the excitement lasts, the animal is completely under their influence. Neither the will, nor emotion, nor physical obstacles, can prevent the limbs from moving.

A hunter gave us the following account: From a considerable distance he had shot at some wild-ducks that were on the water; one of these ducks was not able to fly, and remained on the water, turning in a circle. This duck had received a superficial wound from a grain of lead in the side of its head; it had absolutely no other wound on its body. Now, the curious fact, and what astonished the hunter, was, that this duck could not fly, and yet neither the will nor the means

FIG. 4. A Frog, in which the Left Side of the Cerebellum has been destroyed.

were lacking, nor could it even plunge, which wild-ducks usually do when wounded, if they cannot fly. Notwithstanding the approach of the dog, and the evident very energetic action which its brain sought to exert at this moment on its movements, it could only swim on the surface of the water with a forced movement of rotation.

When the lesion is made on the two sides, some of the same phenomena are seen; only, as the stimulus to activity on both sides is the same, the animal moves in a right line. We have injected mercury in an opening made with a trepan into the upper part of the cranium of a young cat. In a little while, the mercury, by its weight, having reached the base of the brain, the animal lifted himself up, and plunged forward against the wall, making vain efforts to go straight on; deviating to one side, he continued his course till he encountered a new obstacle, and so on. He stopped only when exhausted, and yet until his death from compression of the bulb, his limbs moved without interruption.

In a man who had all the symptoms of a cranial tumor, we have observed phenomena almost identical with these presented by this young cat. When he had a crisis, he would raise his haggard eyes, and walk straight in his chamber, being guided only by the reflex action of locomotion and by habit. After his crises, he could not remember having walked.

It is evident that, in these cases, it cannot be a question of paralysis, and that the phenomena are the result of excitation of the locomotive centres. If the influence of the cerebrum, on one side, is obliterated, and the locomotive centres are not irritated, they act only when they are solicited to activity by movements impressed by the opposite side, and then these movements are forced and automatic, but regular and without exaggeration. The result is, a movement in a circle, which occurs when the animal can change his place. If, on the contrary, the centres are directly excited, the impulse is forced, and the animal is obliged to move in the way impressed by the centres.

Better to comprehend the rolling movements, we must explain some facts which have not been dwelt upon, and which we observe in animals in repose. In lesions of the cranial centres, when we wound the *pons Varolii*, the animal has no longer the same exterior carriage; he leans to one side or the other, according to the side where the lesion is made. All the muscles of this side are then in a state of permanent contraction. The frog represented in Fig. 2, from which have been removed only the cerebral lobes of the two sides, is remarkable for the regularity and the symmetry of the position of his limbs. Placed in the water, he rests on its surface, and the right side is at the same level as the left side. But, if we wound the cerebellum on one side, whether the cerebral lobes are intact or removed, at once the exterior carriage becomes that which is represented in Fig. 4. In this frog, the cerebellum has been destroyed on the left side, and instantly the entire right

side experiences a permanent contraction. This attitude is so regular in these lesions that, from simple sight, we can indicate the direction of the movement of rotation. The opposite side has also a constant and typical attitude; the throwing out of the fore-leg from the thorax is always as is shown Fig. 4.

When this frog is placed in water it turns on itself, the right side serving as the axis of movement. When it is at rest in the water, it takes the attitude represented in the figure. The right half of the body sinks in the water; the limbs of this side can never be on a level with those of the opposite side. These last, on the contrary, especially when the cerebral lobes are removed from the two sides, float on the surface and counterbalance the influence of the opposite side; the hind-foot of the uninjured side remains extended, and rests always at a higher level than that of the opposite side; the fore-foot comes out of the water, as well as the anterior part of the body. The limbs of the affected side are not really paralyzed, but, nevertheless, their movements are more limited, they are not so extended nor so various, and their action no longer coincides with that of the healthy side.

FIG. 5.

A Frog, in which the *Pons Varolii* has been mutilated on both Sides.

If, in place of pricking or deeply wounding one side of the *pons Varolii*, we prick or wound these nervous centres on each side, a little above the bulb, we obtain a tonic contraction of both sides of the body, and the frog takes the attitude represented in Fig. 5, an attitude due, without doubt, to a tonic contraction of all the muscles of the body. Put in the water, this frog falls to the bottom and remains motionless.

Considering successively the attitudes taken by the frogs from Fig. 2 to Fig. 5, we see perfectly that, when we get beyond the cerebral lobes, all lesion of the other parts of the encephalon leads to a sort of

tonic contraction of the muscular groups corresponding to the wounded side. The nearer the lesion is situated to the bulb, the more pronounced are the phenomena, and the more the frog leans to one side.

In geese and ducks, on pricking or cutting the peduncles of th cerebellum, we can well observe phenomena analogous to these seen in frogs. When we remove the cerebellum of the two sides, there is no movement of rotation, but the animal plunges deeply into the water. In the uninjured duck, for example, the thorax penetrates the water but a little way; the duck, deprived of its cerebellum, penetrates it twice as far. The duck, represented at Fig. 6, is wounded in the right side of the cerebellum, and the animal has a movement of rotation toward the left side.

We think these phenomena are due to an irritation of the locomotive centres, and, with Brown-Séquard, we believe that the lesions of certain points of the encephalon engender a state of irritation, whence arises, whether directly or by reflex action, a tonic contraction of certain muscular groups, and chiefly of muscles of the thorax.

It is very easy to account for this influence of the muscles of the thorax in producing the movements of swimming. This easy experiment shows us, at the same time, that simple paralysis, or the loss of function of one side, does not occasion the movements of rotation. If we swim with one arm and one leg of the same side, we do not deviate, but advance in a right line; but, if we contract the muscles of the thorax of one side, at once we lean in the water on that side. If we increase this contraction, we draw over a little more in the same direction, until we come to lie completely on one side, and at this moment there supervenes a movement of rotation, almost instinctive, which makes us spasmodically take the normal position. It is something like this which occurs in animals that have movements of rolling.

By encephalic lesion, animals are led to lean strongly to one side, an attitude which they take even in repose. At the least movement, they are drawn over upon the back; at once, spasmodically, all the limbs concur in the effort to regain the former state; but, as soon as taken, the compulsion of the injured side is reproduced, and, as the animal has already acquired motion, this carries it beyond the normal attitude, and leads it on to its side and back; immediately it seeks to get on its feet, rises, is again drawn over on one side, and so on. When the cerebral lobes are removed, animals cannot remain lying on the back. They always seek to recover their normal attitude, and, consequently, when they have deviated from it, all their efforts go to recover equilibrium. It is at this moment that the four limbs concur to execute the gyratory movement. There are two factors in the motion of rotation: the first is the contraction of the muscles of the injured side which makes the animal lean over and bear down on that side; the second is the coöperation of all the members, as soon as the animal is reversed, to produce a half-revolution and recover the normal forced

attitude. The first turn, particularly when the lesion is old, is slower and less regular; the second is rapid and spasmodic. The first is the consequence of the lesion, the second is the consequence of the regular action of all the nervous centres; and, the better to express this thought,

Fig. 6. Duck, wounded in Right Side of the Cerebellum.

we may say that, in an animal from which have been taken only the cerebral lobes, we might obtain a movement of rotation if, as soon as the animal is on his fore-feet, we turn him on his back; external interference would replace in this case the action produced by lesion of the *pons Varolii.*

We think we have demonstrated that, in an animal deprived of the cerebral lobes, the integrity of the movements of the whole body is perfect; that it is due to the action of the locomotive centres of activity, which is inevitable and always the same after certain excitations: moreover, that in these conditions there are a complete solidarity and compulsion of the movements, and a necessity for the members all to concur in maintaining an equilibrium; finally, that the movements of rotation are due to a disturbance in the equilibrium between the different locomotive centres.

VENTILATION, AND THE REASONS FOR IT.

By ROBERT ANGUS SMITH, Ph. D., F. R. S.

IT is often asked how much fresh air we must allow to come into a room in order to keep it wholesome. The amounts vary so much that we shall never be able to answer the question as it arises in all its changes, unless we consider our reasons for ventilating.

The first is certainly the dislike to organic-smelling substances evaporated from living beings. As some of them are very volatile, a very little rise of temperature increases their amount; and, in warm weather, we require a change of air so frequently, that we cannot make any use of the carbonic-acid test. The amount of change is infinite; we require it for every breath, and we do not consider whether a door is sufficiently open; we open all doors and windows, or leave the house entirely.

Let us take the other extreme—a very cold room—an Esquimaux ice-hut. The amount of air wanted is wonderfully small; we do not know how much the carbonic acid may rise, but it must be very high. The organic matter is frozen, and is probably condensed on the ice; it may be inhaled as a solid, and in a form not to affect the smell. For a similar reason we require less ventilation in cold weather: it is not foolish, as some will endeavor to persuade us, to take less, but it is a natural instinct. We object to the cold, and we learn that heat is a more pressing want than even pure air, whether the organic matter affects our senses or not.

The next reason for ventilating is allied to the first; we say it is to produce freshness. This means that, although all the air of the room be quite new, it has received a something from the surfaces in the room which must be cleared out. This is the reason that housewives like to keep the doors and windows open, and allow the air for a time to blow through the house. This process removes the last particles from the furniture, and is that finish which polishing cannot give. If

the undefined impurity exists in large quantities, only rubbing can remove it rapidly, and this is done when we clean thoroughly walls and furniture. If very bad, and time presses, while elegance is not a demand, we cover the whole, and find whitewashing to be a ready mode.

The other reasons for ventilating have arisen from scientific inquiries. We wish to remove the carbonic acid; we might be able to find this gas by the senses, if it were very abundant; but it is not so as a rule, until after our senses have informed us of the organic accompaniments. It furnishes, however, one of the most important and probably the most important of the reasons in every-day life, because carbonic acid is the most rapidly hurtful to animal life of all the emana tions from the person. It lowers the vitality rapidly, and kills with indefinite warning. The best warning is the organic matter, which acts for both. The warning by carbonic acid is called indefinite, because people lose vitality, but do not observe that the cause is in the atmosphere, there being no smell connected with that gas. At night, when lights are burning, the carbonic acid warns better than the other impurities, by simply putting out the candles. This seldom occurs in private houses, but dim burning is common enough. Mr. James Napier, F. C. S., tells me that he has seen the candles beginning to go out in a small meeting-room in the country, which had a low ceiling and was crowded. It was needful to keep the door open. How blunt, then, is our perception of carbonic acid!

Another reason for ventilating is to remove solid floating bodies, including infectious matter, fungi, and peculiar emanations arising from disease or other anomalous conditions. These floating bodies can sometimes be distinguished by the sense of smell—in the case of mould, for example. If it were possible to describe a smell completely, this class would be largely subdivided, since experience has made many persons very learned on this subject. It is, however, a knowledge which we have not yet been able to receive from or communicate to others. This whole question requires careful examination. The knowledge of the smell cannot be taught, but it may guide us to much that can be taught. Ventilation for this class of bodies will be probably much more attended to in future; care must be taken to drive them to the nearest opening, and not to allow them to diffuse themselves through the room in which they may be produced. In some cases resort must probably be had to rapid artificial and heated currents.

We ventilate to remove smoke and ordinary dust; these are easily seen; and we use ventilation to procure dryness. Moisture rises constantly from the skin, and, if an inhabited apartment is not ventilated, that moisture accumulates. By opening the windows we cause floors to dry sooner, and we remove moisture from all the apartments, and that moisture has generally organic matter with it. If we ventilate with very moist air, we shall dry nothing; if we have very dry air, we may dry too thoroughly. It is, however, better for us to have what is

called practically dry air—that is, air capable of containing much more moisture than it has. The amount of drying work done is according to the dryness, warmth, and speed of the air; with little of these qualities, a great bulk of air is required, where otherwise a small bulk might have sufficed. By warmth and dryness we have an advantage in requiring less rapid currents. I have said elsewhere that a climate has a certain advantage from being very rainy. To call dryness an advantage is not a contradiction. When rain falls and washes the air, we can feel the benefit; when the substances floating in the atmosphere are dried up, we can imagine the advantage; but when the air is kept loaded with moisture which does not fall as rain, and is not carried off by wind, we can easily understand why the results should be hurtful. That it is not the watery vapor itself that injures may be learned from dye-houses, where men spend their lives in all conditions of dampness, sometimes in steam dense enough to make it difficult to see to the distance of a yard. There they have not the heavily-laden moisture of hot, damp climates with rich vegetation, and they have abundant warmth, so that the moisture is not used for absorbing heat and producing colds.

The demands of ventilation would best be explained if we could reply to these questions: What is the smallest amount of carbonic acid which may be call injurious? and what is the smallest amount of organic matter?

The amount of carbonic acid in the air is under .04 per cent. in places that are healthy, but not above .032 in the most open and healthy places. About five times that amount affects a candle sensibly, a photometer being used, and it is extremely probable that less affects it also. Are human beings affected as readily? I rather avoid this question at present; we have not facts enough. We will now speak of the gas in conjunction with organic matter.

Let us take the two together, and we then find that much depends on the temperature also. If the day be warm, we may pass from a room having .06 in a hundred of carbonic acid to the air with .03, and feel refreshed. If the day is not warm, we do not feel the difference; at least, such persons as I have examined do not. *The conclusion is that, in the early stages of the want of ventilation, the organic exhalations are the most injurious.* Now, these increase with the temperature, while the acid does not. For this reason we ventilate in warm weather for the organic matter far more than for the sake of the acid. As the former has not hitherto been estimated by weight, we may view the subject only in relation to the carbonic acid. I think it probable that we shall be able to view it also in relation to other substances. For example, so much temperature will represent so much organic exhalation, and the volume of air will differ accordingly.

When the ventilation is desired to be very good, the amount required when pure air is supplied is much less than with imperfect air.

As the demand becomes less, the difference diminishes. If ozone were taken into consideration, the difference would probably be much greater; but I do not know what allowance to make for that body, and leave it out of consideration. In the smoky towns there is *none* at all.

The conclusion has been drawn by some scientific men that in all spaces, and under every circumstance, the same amount of air must be supplied. Now, it is true that the same amount is to be actually breathed, and, if this breath is thoroughly mixed with all the air of the room, the same amount must be supplied for ventilation, whatever the size of the room. But let us suppose—the most common case—that the thorough mixing does not take place, and we have at once a different amount of air required.

As to the imperfect mixing, it is so various and characteristic that we cannot reduce it to rules; we may hold a smoking substance in the midst of an apartment, and find the smoke go directly to an opening without mixing with the air of the room. It goes, too, with a velocity greater than that of the air of the room, otherwise an opening must be supposed sufficient to change the whole air of the room in a few seconds, that being the time required for the smoke to reach the opening. If we could drive the impure air in a similar way in a narrow current toward its exit, we might manage ventilation with a very small amount of air. To do this is a matter of great importance, because the expense of building is becoming so great, that very few men can afford to pay for a large enough house, and, while rents are rising, the rooms of the middle classes have actually diminished in some places, and within these few years. Yet the evil of small rooms is great, because rapid currents are required for ventilation; cold currents are hurtful, and the warm difficult to obtain. If, however, we could obtain warm-air currents, it would not be important for us to have the rooms so large. It is a question of price. I believe the warmth must be obtained as the first demand of Nature, and without it civilization will go back. When men are cold, they give themselves to physical exercise, and, if that is impossible, to discomfort, in which the mind refuses to do more than to complain, if it cannot forget. Which is cheapest for us? Is it to build large rooms and to have less warmth with slow currents, or to build small rooms and to have more warmth with rapid currents? It is to be wished that the former should be the rule for private houses; more comfort and convenience are promised, and mechanism is not required; if it were, it could not be obtained. For hospitals, the use of mechanism is more within possibility. The expense of large rooms, when the architecture is of a kind intended to ornament a capital city, is very great. Should we not gain by a judicious system of warming? Our methods of warming are very cumbrous, and we seem to be behind ancient Rome and modern Russia. We warm the air which changes in a moment when a door

or window is opened, and we do not warm the house itself. Builders make the walls thinner in these days, and we sit at a fire very much as savages do over a blaze in the open air.

This is less the case with large rooms, where we require slower currents. We may next ask, Is there any advantage in rapid currents at any time? There is; in the case of infectious diseases, it would seem in the abstract to be of the greatest importance that the patient should be in a current, speaking as a chemist, and not a physician. The first reason is for his own sake. Even in health we poison ourselves, and in disease we tend more rapidly in the same direction. Infectious emanations may be collecting round a patient, and, if so, the still air will keep them more carefully near him. I speak only generally, and do not enter on the hospital controversy.

Perhaps we cannot have rapid currents in large rooms very easily, so much air is required; but we can have frequent changes of air. It is clear, however, that the rapid removal of the air collecting around patients with infectious diseases, and probably also non-infectious, is most likely to promote health, both in the patients and in the attendants. Few people can stand the rapid motion of cold air, and, if we must have rapid currents, they must be heated.

The source of the air with which we ventilate ought probably to be high in all cases, but even here we must move slowly. We are not quite sure that any infectious disease ever sends its emanations high into the air. Disease seems to creep along the ground; the causes may be at a considerable height, but we are compelled to suppose them very thinly disseminated there; and the action seems to be according to quantity as well as intensity; toward the surface they congregate and are active. This we see from the evening air, especially in marshy places; it is only after a certain repetition of the attack of the more thinly diffused wandering substances falling down from the atmosphere and accumulating, that men yield to the influence. As a rule, it would be unnecessary to purify the air of the daytime, if in an open place, even in average towns; and in most places it would be unnecessary to purify the air of the night in this country. It would, however, be better to warm it in northern and damp climates, and even in temperate climates, in order to produce a difference of temperature between the air entering the room and that within it, even if the necessity arising from the cold of rapid ventilation did not occur. In inhabited rooms the moisture increases as much as the organic matter, and the condition of the air is similar to that of the evenings of summer: whenever the temperature goes down a little, there is a deposit of dew; but, when the warmth increases, the air is laden with moisture, and the condition resembles that near a warm close vegetation. In both cases ventilation is wanted. Our walls become saturated with moisture if they are porous, if not porous they are covered with streams of water. The moisture has organic matter in it which

is not removed by mere drying, and the effects are very long in leaving. We may know this from breathing the air of any bedroom in a London hotel, or in most private houses in towns. People are afraid to keep their windows open, because of the smoke without, and so they retain the organic matter. We can readily smell this, even if arising from healthy persons, and it has ceased to be a matter of surprise. If unhealthy persons are present, unhealthy matter may be expected to diffuse.

If, then, any disease is propagated by organic germs living on the organic matter of the atmosphere, or associated with it, it is not at all wonderful that the disease should lurk in corners of houses, in clothes, or other porous matters, simply because we can trace floating matter to its lodgment in such places.

It is remarkable how readily porous bodies absorb the moisture of the air, and substances with it. I find that the leather on the bookcases in my study, where gas has been used, is made rotten, and in exact proportion to the height, the highest being so frail that it can scarcely be handled, while the lowest is still pretty firm, although much less so than at first. The amount of sulphuric acid in the pieces is also in proportion. The intermediate are affected in an intermediate way. No better proof can be had of the absorptive action of these porous substances, and of the unequal state of the atmosphere in various parts of a room.

When rooms which have absorbed organic matter have been shut up, the original peculiar smell ceases, and a musty one takes its place; we recognize something which instantaneously brings that of mould to our minds. We cannot doubt that the air in such cases is full of the spores of such plants; the plants themselves grow in abundance, and we know well that when they grow they readily send out colonies. The leather of the bookcase was said to show the inorganic bodies; the books themselves are covered with the organisms when care is not taken, so that one small room gives an epitome of the whole subject. We have here, therefore, no mysterious agent, but one that is perfectly plain. Why should the agent be mysterious in the case of the infectious disease? It is only so far a mystery—we do not know the different plants or organisms, and so cannot tell whether we have health or disease in them by merely examining them through a microscope.

If porous substances have the characteristics alluded to, why use them? There are some difficulties here. If a wall is to be cleaned frequently, and rubbed when wet, it is better that it should not be porous. That seems quite clear; but when these processes cannot be undertaken, it really seems as if it were better to have it porous. Such substances absorb moisture in some seasons, and give it out slowly at others. Our clothes are of this kind. It is not possible to have warm coverings not porous. Porous bodies hold also a good deal of air, and they cause oxidation more readily. Nature has employed them for

disinfection more than any others. The whole soil of the earth is a great disinfectant, kept in constant activity, being constantly required, holding in itself the most nauseous and unwholesome things, and still having healthy people living over it. However, the soil may be too full, and at times it becomes so, and therefore we run to places which cannot contain much impurity, such as bare rocks; and in such places we obtain pure air. If in houses we have too much organic matter for the porous substances to oxidize, we must resort to non-porous surfaces; but then they must, like the rocks, be often washed, or excessively exposed to the air or the warm sun.

To purify rooms the air must blow long into them, or every part must have the organic matter rubbed off by the hand. This is a sufficient rule for both hospitals and private houses. Good rubbing will purify furniture, and this our housewives know; long-continued currents of air are also known to be good, but better as a supplement to rubbing. The rules are very easy chemically, but mechanically they are difficult. This is merely a repetition of that which has been said elsewhere, and long ago, although it is here stated in other words. The world must be told every thing in ten thousand different ways before it learns, and it is wearisome to repeat the lesson. I am only saying, also, what every clean house-keeper carries out; and yet there is an apparent novelty in it when we compare it with the sayings and doings of many persons, intelligent and observing although they be. —*Air and Rain.*

PROF. JAMES D. DANA.

MODERN science, in giving rise to a new order of knowledge, fundamentally contrasted with the older eruditions, among its numerous influences cannot fail to give us a more satisfactory basis for the estimation of mental character and attainment. In proportion as the later knowledge is definite, positive, and universally accepted, does it become a better standard by which the intellectual greatness of men may be judged. In no sphere of mental performance can a man's work be brought to such decisive tests as in science. Each department has its special and authoritative cultivators who subject all new ideas to an inexorable ordeal of verification. While, in the various fields of literature and art, reputations may be made with little regard to substantive merit, because their appeal is to taste and feeling, and the canons of criticism are uncertain, in science, on the other hand, the rules of judgment are unmistakable, and men are measured by the quality and extent of what they have really accomplished. Human nature is, of course, imperfect, and in science, as elsewhere, its imperfections may

often interfere with the awards of justice; but here, more than anywhere else, errors of personality are eliminated by the impersonal tribunal to which all questions are at last referred. A pretty definite idea is conveyed, when it is said that a man has "mastered a science." He must have made himself familiar with a certain body of facts and principles, with their historic growth and their degree of development. But the familiarity here implied is not that which is current in the walks of literature. It is not to be gained merely by reading. It implies a direct knowledge of the phenomena themselves—knowledge at first hand—and the exactions in this sphere of thought go further still. A man cannot be said to have mastered a science until he has thoroughly possessed himself of its method of research, and proved this thoroughness by successful, original work. He must have contributed to its advancement, to its original stock of observations and inductions, and done it so effectually that those who stand highest shall recognize the validity and value of his work. This condition being complied with, the number of sciences that have been successfully pursued, and the degree of their complexity, become fair measures of the mental breadth, grasp, and power of the minds engaged upon them. Humboldt was preëminent because of his conquest of many sciences. Helmholtz has a high place in European science because he is confessedly strong in mathematics, physics, and physiology, and has combined the researches of these sciences in carrying on his original investigations. Judged by this standard, the subject of the present sketch must be assigned an eminent position in American science, as he is an acknowledged master in the three extensive departments of mineralogy, geology, and zoology, having made original investigations of great value in all these fields of study.

Prof. DANA was born, in 1813, in Utica, New York, where he passed the first years of his life. He seems to have had an early inclination to the sciences, as at seventeen years of age he entered Yale College, attracted by the fame of Prof. Silliman (Sr.), the distinguished pioneer in American science. During the regular course of study at New Haven, Mr. Dana evinced an especial love for the natural sciences, without neglecting philological and mathematical pursuits, in the latter of which he was distinguished. He was graduated with honor, Bachelor of Arts, in 1833, and about the same time received the appointment of teacher of mathematics to midshipmen in the Navy of the United States. In that capacity, he sailed to the Mediterranean, in the United States ship-of-the-line Delaware, returning in 1835. During the two years following, he acted at Yale College as assistant to the distinguished professor whose successor in office he afterward became.

In December, 1836, he was appointed mineralogist and geologist of the Exploring Expedition then about to be sent by the Government of the United States to the Southern and Pacific Oceans. The five

vessels of the squadron, under the command of Commodore Wilkes, sailed in 1838, on a voyage around the world. After extensive explorations, and suffering shipwreck, moreover, at the mouth of the Columbia River, in Oregon, Mr. Dana returned home in 1842. The rare opportunities which this voyage afforded for scientific observation had been well improved. During the thirteen years after its termination, he was engaged in preparing for publication the various reports of this expedition committed to his charge.

Mr. Dana resided at Washington from 1842 to 1844, and then returned to New Haven, Connecticut, where he, soon after, married Henrietta Frances, third daughter of Prof. Benjamin Silliman, and where he has since resided. Before going to the Pacific, he published, in 1837, the first edition of his "Mineralogy," of which the fifth and last edition appeared in 1868. This is a work of high repute, both in America and Europe.

His first publication connected with his observations in the Exploring Expedition was a "Report on Zoophytes," which appeared in 1846, a quarto volume of 740 pages, with an atlas of 61 folio plates. In this work Mr. Dana reviewed the whole department of Polypes, combining his own observations with those of earlier authors, and proposed a new classification, bringing, for the first time, the Actiniæ and the Alcyonoid Polypes into their true relations to the Astræoid Polypes. The number of new species which he describes is 230.

The second work in the same series was a "Report on the Geology of the Pacific," published in 1849, a quarto volume of 756 pages, with an atlas of 21 plates. This work presents a view not only of the geology of parts of Australia, Western America, and the islands of the Pacific, but also treats at length, and with original views, of Volcanic Phenomena, Coral Reefs and Islands, and the General Features of the Globe.

The third work pertaining to this Government Exploring Expedition was a "Report on Crustacea," which appeared in 1852–'54—the text, 1,620 pages quarto; the atlas, 96 plates in folio: 680 species are described in this work, of which 658 are new. The subjects of Classification and Geographical Distribution receive in it special attention. These reports were published by the Government of the United States, and only 200 copies of each have thus far been issued. With few exceptions, the drawings in these atlases were made by Mr. Dana himself.

While engaged in preparing the last two of these reports, Mr. Dana has been the active editor of the *American Journal of Science and Arts*, founded in 1819, by Prof. Silliman, Sr., and well known as the great repository of the scientific labors of their countrymen. To this journal, which has now in 1872 reached its 103d volume, as well as to the Proceedings of the American Academy of Arts and Sciences, in Boston, the Lyceum of Natural History, of New York, and the Acade-

my of Natural Sciences, of Philadelphia, Mr. Dana has contributed various important memoirs.

Soon after the resignation by Prof. Silliman of the chair of Chemistry and Geology in Yale College, Mr. Dana entered, in 1835, on the duties of the office of Silliman Professor of Natural History and Geology in that institution, to which place he had been elected in 1850; his brother-in-law, Prof. Benjamin Silliman, Jr., having been appointed to the chair of Chemistry. Prof. Dana is now engaged in discharging the duties of his professorship, and in editing the *American Journal of Science.*

In 1854 he was elected president of the American Association for the Advancement of Science, having been for many years one of the Standing Committee of that body; and in August, 1855, he delivered the annual address before that Association at its meeting in Providence.

Besides the works already referred to, Prof. Dana is the author of the following publications: "Manual of Mineralogy," 432 pp., 12mo. New Haven, 1851. 2d ed., 1857. "Manual of Geology," 1862. Rev. ed., 1869. 800 pp. "On Coral Reefs and Islands." 8vo, 144 pp. New York, 1853.

Mr. Dana's more important papers, in the *American Journal of Science and Arts*, are:

First Series, vol. xxx., 275, "On the Formation of Twin Crystals." xxxiv., 225, "Anatomy of the Caligus Americanus." xlv., 131, 310, "Areas of Subsidence in the Pacific indicated by the Distribution of Coral Reefs and Islands." xlix., 49, "Origin of the Constituent and Adventitious Minerals of Trap-rocks."

Second Series, ii., 335, "On the Volcanoes of the Moon." iii., 94, 176, 381; iv., 88, "On the Geological Effects of the Earth's Contraction and Origin of Continents." iv., 364; v., 100, "On Cohesive Attraction." ix., 220, 407, "On Isomorphism and Atomic Volume in some Minerals." xvi., 153, 314, "Isothermal Chart of the Ocean." xvii., 35, 210, 430, "Homœomorphism among Minerals." xviii., 85, 131, "Homœomorphism of Minerals of the Trimetric System." xviii., 314; xix., 6; xx., 168, 349, "Geographical Distribution of Crustacea." xxii., 305, 335, "Plan of Development in American Geological History." xxv., "On Cephalization." Continued in vols. xxxv., xxxvi., xxxvii., and xli. xliv., 89, 252, 398, "Connection between Crystalline Form and Chemical Constitution."

Third Series, i., 1; ii., 233, 305, 324, "On Glacial Phenomena in New England, and the Source of the New England Glacier."

In 1856–'57 Prof. Dana published, in the *Bibliotheca Sacra*, a series of four articles, entitled "Science and the Bible," called forth by a work of Prof. Tayler Lewis, on the "Six Days of Creation."

Prof. Dana's last work, "Corals and Coral Islands," 398 pages, with 279 cuts, is just published (1872).

EDITOR'S TABLE.

MAN AS AN OBJECT OF SCIENTIFIC STUDY.

IT will now scarcely be questioned that the law of progress in education is a tendency toward limitation of mental pursuits. Under the theory of education as a discipline, knowledge is held subordinate, but it is obviously rising in educational value, while it is beginning also to be understood that mental discipline may be acquired in any field of study by the vigorous and methodical exercise of the mental powers upon its subject-matter. But, with the increasing importance of knowledge, there comes a difficulty from its vast extent. Every thing cannot be learned; if some subjects are chosen, others must be passed by; indeed, but few can be taken, while many are left, and so study is inevitably specialized. This raises the further question of the rule of choice, or the relative value of the knowledges. What are the most necessary things to be generally studied, and which shall have the first place in any system of mental cultivation that goes beyond the barest rudiments? This we take to be now the urgent and fundamental problem of education.

Among the articles of our present number, we publish an abstract of an address before the theological students of Yale College, by Mr. Beecher, on the "Study of Human Nature." He presents, with his usual force, the claims of this subject upon students of his profession, but the reader will hardly fail to remark that his argument is much broader than its professional application. It is certainly necessary for clergymen, who aim to instruct and elevate their hearers, to understand their natures, if they would work effectually. It is, in fact, a simple business necessity; and, if neglected, it will entail the same consequences that ignorance of the material in which he works entails upon the artisan; that is, failure. But this necessity is a thousand times greater in the case of the teacher than in that of the preacher. For the teacher takes the human material directly in hand in its plastic period, to shape and inform, and he works at it day by day and all day long. That the study of human nature, systematic and prolonged, is incumbent upon the faithful teacher is self-evident, but what, then, shall we say of its necessity to the parents who give their life to the new being, and make those deep initial impressions that affect the unfolding nature more profoundly than all that is done afterward by teachers and preachers combined?

But it is not as fitting preachers, teachers, or parents, for their special functions, that we are now impelled to demand that the scientific study of human nature shall take a high and universal place in education. It should be done because this knowledge is of first and fundamental importance to all. Living in complex social relations, incessantly in contact with others, acting upon them and acted upon by them in innumerable ways that vitally involve the mutual welfare, it is certainly of the highest importance that each person shall comprehend the qualities of the natures that are thus brought into reaction. But it is needless to enforce the old injunction "know thyself," or to insist upon the correlative duty of knowing others also. The want will be freely admitted: the question is how it may be supplied.

Mr. Beecher maintains that "one of the prime constituents of clerical training should be a study of the human soul and body from beginning to end," and he insists furthermore that

this study should be pursued by the method of science. The importance of this last requirement cannot be overestimated. The study of man should be first of all scientific, because that is the only method which aims solely and supremely to arrive at the truth. It is well to study human nature for the sake of professional utility; but it is better to study it for the intrinsic and exalted character of the knowledge itself. It is more important to insist upon this, because on no subject is the bias of prejudice and prepossession so all-disturbing as here. Human beings should be studied exactly as minerals and plants are studied, with the simple purpose of tracing out the laws and relations of the phenomena they present. Men should be analyzed to their last constituents, physiological and mental. They should be observed in their characters and actions, in their general attributes and peculiar traits; they should be apprehended in their growth, in their normal and abnormal manifestations, in their relations to inferior life, in their social and sexual attributes, and in their relations to vocations and institutions, and the whole inquiry should be pursued in that unimpassioned spirit of true science which cares little *what* the facts may be, but every thing to *know* what they are.

Human nature is certainly a very comprehensive and complicated subject, and as a science it is, of course, profoundly imperfect. It is by no means to be taken up as one of the ordinary sciences, and pursued separately, like mathematics or electricity. Those branches of science upon which it chiefly depends are to be acquired first as a foundation, and then they are to be combined in the direct and practical study of man himself, in his totality, and as a subject of systematic observation. Human nature, like geology, is dependent upon other sciences for its data, and then it offers large additional questions of its own, which require a scientific training to deal with them. When the geologist has mastered the laws of physics, chemistry, mineralogy, meteorology, zoology, and botany, he then goes out to commence the practical study of the rocky masses which compose the earth's crust. In the same way the scientific student of human nature will first get an acquaintance with the principles of biology, which throw light upon man's physical constitution and relations, and then he must master psychology, or the science of feeling and intellect, as manifested in the grades of life, and these will prepare him to form a right conception of the individual man in his bodily and mental unity. All this, however, is of little account in itself, and is but a preparation for the direct study of human beings, their characters and actions, as matters of habitual and methodical observation. What is required of our enlightened educators is, to arrange the scientific curriculum with a view to this great end, and then to pursue the study into its higher and practical applications. If it be said that we can never know the truth about people, as half of them give their lives to the art of keeping up false appearances, the reply is, then study that fact first, and get a cool scientific expression of the extent, limits, and value of this source of error; a long stride will thus be taken toward the end we propose.

This study is undoubtedly great, complex, and difficult, but it is, nevertheless, intrinsically practicable. Thanks to science, the knowledge exists. An immense body of truth of the character here indicated has been wrought out, but education as yet ignores it. Between the vast system of facts and principles which science has established, and the state of the general mind, there is a gulf wider than the Pacific, and it is still daily widening; for, while there is greater activity now

than ever before in the world of scientific inquiry, the masses of the people are doing little or nothing to avail themselves of it.

Complex and difficult the scientific study of human nature may be, but it is demanded by the imperative exigencies of the age. What is wanted is a better knowledge of human relations in the social state; and that resolves itself immediately into a better knowledge of the beings which exist in that state, for society is what its human units make it. Ignorance of men, of the nature of their weaknesses and vices, and the springs and laws of their action, is at the root of the chief impostures by which society is scourged. The quackeries of the platform, the bar, the state-house, and the pulpit, the gigantic swindles of speculators, and the frauds of petty traders, the omnipresent over-reachings and deceptions by which people are victimized in the intercourse of life, are but legitimate consequences of the gross and wide-spread ignorance of human nature. We are deafened with the discordant cries of political and social reformers; but here is where they must begin, if any thing valuable and permanent is to be accomplished in the way of reform.

THE DISCOVERER OF OXYGEN.

Several thousand people assembled the other day in the Central Park to unveil the statue of Shakespeare. The ceremonies were impressive. The illustrious English poet, newly done in bronze, was celebrated prosaically by the most illustrious of American poets, and then he was glorified poetically by another distinguished American poet, while this effect was heightened by the fine vocalization of our eminent interpreter of the great dramatist, and altogether it was a most poetic and Shakespearian affair.

Such an event will suggest different reflections in different minds; we are in the mood of contemplating it chemically. As the symposium is ever qualified by the libations, it will be asked what they had to drink. As befitted the exaltation of the hour, they drank the invisible ether that is never conveyed in goblets—a solar distilment of the beautiful foliage of the park, and to this they owed all the inspiration of the occasion. The afflatus was an immediate effect of oxygen gas. It was through it and by it that the entire concourse lived, and moved, and had its poetic being. As the first condition of cerebral action is a constant stream of oxygenated blood driven through the brain, the broad current of thought and feeling in the assembled multitude was sustained by this element of the vital stream. That withdrawn, the prose of Bryant, the poetry of Stoddard, and the elocution of Booth, with the appreciative applause of the audience, would have suddenly and simultaneously ceased. For, whatever may be the case in other spheres of being, in *this* sphere the spiritual world of thought and feeling is created, instant by instant, by the chemical energy of oxygen. Let none accuse us of materialism, for this doctrine has high and sacred authority. In its account of human creation, the oldest scripture declares that God "breathed into his nostrils the breath of life, and *man became a living soul;*" and the breath of life we now know to be oxygen gas.

But, for many thousands of years, it was not known. Humanity had run through a vast career before this truth was reached. Mighty empires had come and gone; great cities had been built and had perished; civilizations had risen and passed away; arts, literatures, philosophies, and religions, had become ascendant and had declined before men found out the constitution of the air—what and why they breathe.

We owe this most brilliant and important of modern discoveries to Dr. Joseph Priestley, of England. He was

a clergyman and a chemist, and in 1768 he went to Leeds, and was settled as pastor over a large congregation. He happened to reside near a brewery, and "accidentally observed that the beer, during its fermentation in the vats, gave forth a remarkable aërial substance. The flame of a lighted stick immersed in it was at once extinguished, and the smoke floating on the top of the stratum showed that it was very heavy, a result which was perfectly confirmed by the observation that, invisible and intangible as it was, it could be poured from vessel to vessel like water; and in the vats, in which it originally occurred, it would overflow their edges, and descend to the floor, along which it would run like a stream, its course being readily tracked by the expedient of putting a lighted stick into it, and observing the extinction of the flame. Moreover, he found that it would dissolve in water, for, if dishes of that liquid were placed where it had access, an agreeably acidulous and sparkling fluid, soda-water, was formed; and, that the agent which brought all these results about possessed a physiological potency, was proved by the fatal fact, too often known in such manufactories, that, if by accident it was breathed, death at once took place."

This substance was then called "fixed air," and is familiarly known as carbonic-acid gas. It is now exactly a hundred years since Priestley published a pamphlet "On impregnating Water with Fixed Air," and a year later he received the Copley medal from the Royal Society for his "Observations on the Different Kinds of Air." In the year 1774, he made the splendid discovery of oxygen, and, in allusion to its power as the sustainer of life, he applied to it the epithet "vital air." When it is remembered that this wonderful substance is the active element of the atmosphere, and essential to the existence and activity of the entire living world; that it enters largely into the composition of all the natural objects around us, forming three-fourths the weight of all living things, half the weight of the rocky strata, and eight-ninths of the oceans; and, moreover, that it is an element of great chemical energy, and is involved in nearly every transformation of matter in the laboratory of Nature, and in the processes of the arts, we shall be prepared to comprehend the significance of its discovery. It has given us a new chemistry and a new physiology, and it probably carries the mind of man deeper into the order of Nature than any other single scientific revelation ever made.

But the great discoverer had his troubles. He carried his independence and power of thought into theology and politics, and his life of course became a turbulent battle with sects and parties. In relation to this part of Priestley's career, Dr. J. W. Draper has well remarked: "We must not impute it to mental weakness, but rather to a pursuit of the truth, that in succession he passed through many phases of religious belief, and four different sects, the Presbyterian, Arminian, Arian, and Unitarian, received him as a votary. This is not the occasion nor the place to explain the causes which led him to this course. It is only for us to judge of so great a man with charity. But, imbued as he was with a deep religious sentiment, and feeling that even the most exalted objects of this life are not to be compared with the importance of another world, he regarded his philosophical pursuits as a very secondary affair, and gave much of his time and talent to controversial theology. He seems to have come to the conclusion that it was incumbent on him to make a religious war. As his biographer says, 'Atheists, Deists, Jews, Arians, Quakers, Methodists, Calvinists, Catholics, Episcopalians, had alike to combat him.' In more than a hundred volumes which he printed, each of these found an adversary of such force and

vigor (and it was impossible with such a man that it could be otherwise), that their ablest theological writers were overmatched. By the established Church of England, he came to be regarded with such feelings, that instances occurred in which those who had successfully answered him were rewarded with the highest dignities; a circumstance which gave origin to his remark, that he appointed the bishops of England. Priestley forgot that the experience of all nations and of thousands of years has proved the utter impossibility of any one man convincing the whole human race, and converting them all to his views. He shut his eyes to that anarchy of opinion infesting the world, brought on in no small degree by such polemics as those in which he delighted. In an exact science, like chemistry, he could describe some new discovery, and every man in Europe at once admitted its truth. He never realized how different it is in politics and theology. The library of volumes he wrote on these topics has already dropped into that gulf of oblivion which has received all the works of the authors of the early and middle ages, and no man cares to learn what he wrote or what he thought of the matter. But not so with his philosophical labors: they stand out clear and distinct, monuments of the advance of the human mind in knowledge and power during the eighteenth century. His discovery of oxygen gas will last as long as the world endures."

But, if Priestley erred by meddling with men's political and religious opinions, he paid the full penalty of it. While living in Birmingham, the mob broke open and sacked his house. His philosophical instruments, most of them made by himself, were broken up; his library and original papers, the fruits of a frugal life, were destroyed, scraps of manuscript covered the floor several inches deep, and his books were strewn over the high-road for half a mile. His life was endangered; he was obliged to flee from the place with his family, and for three days one of the chief cities of the nation was the scene of riot. The blow was crushing. His society was avoided even by his philosophical associates, and, finding that further tranquillity in England was impossible, he resolved to come to America. He arrived in New York in January, 1794, and took up his residence in Northumberland, Pa., where he died in February, 1804.

Such was the career of the discoverer of oxygen; but, as Dr. Draper intimates, while oblivion has swallowed his theology and politics, his scientific fame grows brighter with the advance of knowledge. The rancorous feelings which drove him from his native country have subsided, and a more just generation is preparing to grant his memory the honor that is over-due. Subscriptions are being raised to erect a statue to Priestley in Birmingham.

Would it not be well for the country which gave him refuge to do the same? And apart from the question of doing justice to a great man's memory, which has been obscured for a century, what could be more fitting than to celebrate the centennial of a mighty discovery on August 1, 1874, by unveiling a monument to the illustrious discoverer?

LITERARY NOTICES.

BOTANY FOR BEGINNERS. By MAXWELL T. Masters, M. D., F. R. S., late Lecturer on Botany at St. George's Hospital. London: Bradbury & Evans.

IN form, typographical execution, and illustrations, this is a beautiful book; in its scientific statements it is a sound and trustworthy book; but, for the purposes indicated in its title, it is a worthless book. Dr. Masters knows much about plants, but of the minds of children he seems to know nothing. How long will it take these educational book-makers to find out that there

are two factors in the case, a subject to be presented and a mental organism to be affected, and that the latter, instead of being of small account comparatively, is in reality the first and principal thing? Botany, like the other sciences, can be so presented as to stupefy the mind instead of awakening it. Book-science and scientific books, as generally used in schools, are as often baneful as beneficial; they are merely new resources for loading down the memory with verbal acquisitions. The overshadowing influence, in education, of language which is learned entirely from books, and is mainly an exercise of pure memory upon arbitrary signs and empirical rules, has so determined the habits of education that the sciences have been forced into the same method of acquisition, and the absurd practice still prevails of acquiring them by memorizing the contents of books. Even in botany, where the objects treated of are everywhere—overhead, underfoot, by the way-side, in the gardens, fields, yards, and even in the house, soliciting the attention and kindling the admiration continually—we have still the preposterous habit of studying the subject by committing book-lessons in the school-room. To begin botany in this way with children is worse than an absurdity, it is an educational crime. It violates the law of the mind, by making them learn in a forced and unnatural way that which should be acquired in an attractive and natural way; and, by inducing indifference or actual repulsion, it defeats rather than promotes the true objects of education.

Nor is the case at all helped where the author begins with a general injunction to study the objects themselves, and then leaves the pupil to make his own way without guidance, or, in attempting to guide him, puts him on a false track. This is the sin of Dr. Masters. He puts the beginner at the most complex work of botany the first thing. It is the old story of commencing to pick flowers to pieces, "to ascertain of what parts they are constituted, their number, their shape, in what manner they are pieced together, whether they are separate or joined together, what is their relative size and position in regard to one another, and so forth." The object is to reach classification at the earliest moment, so that the child can begin to name flowers and show off his botanical accomplishments. Although professedly writing for beginners, Dr. Masters tacitly assumes them to be adults, and capable of grasping at first the generalized results of the science. That he begins with the simplest flowers is but little mitigation of his bad method. To attack the most complex part of plant-structure at the outset, using microscopes and making dissections, however possible it may be for matured minds, is neither possible for children, nor is it the true order in which the science should be considered. There is a wide range of observation of the simpler parts of plants which are open to easy inspection, and it is to these that the beginner's attention should first be directed. The earliest thing to be done is to cultivate the art and the habit of observation, and then the pupil will pass naturally to the comparison of these simpler characters, and thus advance imperceptibly to the higher complexities of form and structure. This course is equally necessitated by the order of unfolding of the child's faculties, and by the order of facts in the science itself.

SCIENCE PRIMERS. "Chemistry," by Prof. Roscoe. "Physics," by Prof. Balfour Stewart. D. Appleton & Co.

IN these little volumes the authors have tried very hard to adapt the treatment of their respective subjects to the juvenile capacity, and with very fair success. We think them by no means perfect, but they are probably better than any thing else of the kind that can be got. They were prepared for the English schools, and are the result of the recent commendable effort to infuse more of the scientific element into general primary instruction. The Rev. W. Tuckwell, an able advocate of this reform, thus speaks of them in *Nature:*

These little books illustrate an imperfectly-accepted truth, that systematic elementary teaching is a late and not an early product of educational energy. The best head-masters of our schools have discovered the fallacy latent in our ancient belief that the ablest men are required to teach the oldest boys, and have, in one or two famous cases, acted on their discovery. It is easy for a young man fresh from university honors to pour his knowledge into minds which

have been well prepared, and which approach more or less to the level of his own; but to teach a class of little boys, to realize their difficulties and to appreciate their ignorance, to understand the perplexity which oppresses them in the presence of statements long since axiomatic to ourselves, require a mature and versatile intelligence, a mind which can communicate childish knowledge as readily and as joyously as it solves recondite problems; a combination of rare gifts with long and conscientious training.

And thus it is that the zeal for scientific teaching and the gathered scietnific experience of the last fifteen years have only issued now in the books which form the subject of our notice. Scientific class-books hitherto have been either too difficult or too easy. They have been unavailable for beginners without the intervention of a practical teacher; or, in their effort to be popular and simple, they have abdicated half their value as instruments of educational discipline. In these books both extremes are avoided. Every stage of their teaching is based upon experiment; no law is enunciated till it has been proved. From first to last the student finds himself in immediate contact with Nature. His empirical knowledge of external things is systematized; simple every-day phenomena reveal to him their principles and *rationale;* he walks forth with a new eye to discern the meaning and the beauty of familiar sights and sounds, and with a mind upon the stretch for fresh discoveries. And, on the other hand, no previous training is essential to the teacher who adopts them as his guide. Any man, ignorant even of the first principles of chemistry and physics, yet fairly dexterous and intelligent, who will patiently master the books, and try each experiment for himself, is in a position to transmit their contents successfully and clearly. The officer may lecture to the soldiers of his regiment, the clergyman to the artisans of his parish, the national school-master to the children of his school. Managers of schools, deterred as yet from including science in their course through lack of teachers and of text-books, will find their difficulty removed. . . .We tender them our hearty thanks for work which marks a stage in the advance of scientific education. Its lingering progress hitherto has been owing to the want, not of zealous champions, but of united action. The labors of its advocates are now beginning to converge. The leaders of science and the leaders of education are drawing close together—on the one side eager to impart, on the other ready to receive, advice and guidance. By the publication of these books the most serious of the obstacles which have kept them separate is removed.

MISCELLANY.

Length of Guns.—General Morin, in a discourse delivered before the Paris Academy of Science, noted this curious circumstance, that, though different kinds of powder may give equal speed to a projectile, they may differ very much from one another in the pressure they exert upon the walls of the cannon. He further remarked that all the grades of powder that have been tested undergo entire combustion, and consequently produce all their effect in pieces whose length is 12 times their calibre. But yet the greater part of the field-pieces in use have a length equal to 30 times their calibre. They might be cut down, therefore, without prejudice to their efficiency, and thus their portability would be increased.

Late Researches on the Gastric Juice.—The gastric juice of the human stomach has lately been made a subject of special study by Dr. Leube, of Erlangen, who gives the fruits of his work in an elaborate paper read at the recent Rostock Congress. He obtained the juice for his experiments by means of a tube introduced into the gullet. The gastric juice obtained from the stomach, empty and cleansed by an injection of water, is slightly acid, doubtless owing to the irritation caused by the injection and the contact of the instrument. Its digestive power is weak. In the course of his experiments with this fluid, Leube found that cheese is digested more rapidly than the albumen of a boiled egg, and the latter more rapidly than the albumen of a raw egg.

Experiments made with quassia demonstrate that this substance does not exert any special exciting action upon the secre-

tion of the gastric juice. It excites it only as any other body might, which is brought into direct contact with the mucous coat of the stomach. The action of bitters upon the gastric secretion is, beyond doubt, a reflex action, having its point of departure in the mucous membrane of the mouth.

In the course of the discussion which ensued, Dr. Hoppe Seyler observed that in dogs, when fevered, the gastric juice suffers a diminution of its acid, but not of its pepsin. The white of the egg, in order to be dissolved, must first be transformed into syntonine, which process requires a gastric juice of great acidity. This fact accounts for the difficulty with which albumen is retained upon a disordered stomach. As concerns the digestibility of cheese, that substance is composed of different ingredients, and notably it contains one phosphoric substance, utterly indigestible, nuclein.

Sanitary Reform in India.—Lord Mark Kerr sends a communication to the (East) *Indian Medical Gazette*, in which he relates how he came to discover the cause and means of prevention of what is called the *Delhi Boil*, formerly the scourge of the denizens of Delhi, native and foreign. From a comparison of the situation and surroundings of Delhi with those of other Oriental cities similarly noted for the prevalence of boils and sores, he was led to conclude that the cause of the disorder was to be found in the existence, within the walls of the town, of a barren strip of land, two miles in length, by 500 yards in breadth, covered with foul weeds and ruined buildings, with the wells and water-courses choked up. He proposed to clear the water-courses and plant trees and grass. This was done in 1864, and now the Delhi Boil has entirely disappeared from the city. Lord Mark Kerr desires to have his experience tested throughout India, for he believes that pure irrigation and draining, with judicious planting and gardening, would greatly tend, not only to remove sores and such-like evils, but to prevent the approach of more serious and even fatal scourges.

A New Anæsthetic.—The *Medico-Chirurgical Circular* (German) calls attention to a new anæsthetic, which has received the name *Aethelid Chlorid*. Dr. Langenbeck has employed it in six operations, and found that it produced anæsthesia more rapidly than chloroform. He states that its use is unattended with any of those unpleasant effects which commonly attend the exhibition of chloroform. Also a new method of producing anæsthesia with morphine has been discovered. In this method hypodermic injections of the chlorhydrate of morphine are given, followed up with light inhalations of chloroform. Three cases were cited where this method had been employed satisfactorily. The anæsthesia, in this case, is not attended by sleep, and it leaves the action of the mind, the senses, and the voluntary muscles intact.

Liebig's Extract of Meat.—Liebig's process of obtaining meat extract is found to yield only 14 per cent. of the dry, solid material of the meat. The remaining 86 parts are the really nutritive constituents of meat, and the 14 contained in the Liebig extract are merely stimulative, not nutritive. This is, with ingenuous candor, admitted by Liebig himself. An English pharmaceutist, Mr. Darby, claims to have invented a process of obtaining, in concentrated, soluble form, *all* the constituents of the meat. His process, which has been patented, is this: Lean meat, finely sliced, is digested with pepsin, in water previously acidulated with hydrochloric acid, at a temperature of from 96 to 100° Fahr., until the whole of the fibrine of the meat has disappeared.

The liquor is then filtered, separating small portions of fat, cartilage, or other insoluble matters, and neutralized by means of carbonate of soda; and finally carefully evaporated to the consistence required, namely, that of a soft extract.

The resulting extract represents, in all its constituents, the lean meat employed, but with the fibrine, albumen, and gelatine, changed into their respective peptones, or soluble forms. This change is effected solely by the pepsin and hydrochloric acid, or artificial gastric juice, without the evolution or absorption of any secondary products.

But this process, whatever care be taken, leaves the fluid meat with a strong *bitter* taste, which always attaches to meat digest-

ed with pepsin. "In order to remove this bitter taste, I have made," says the patentee, "very many experimental researches, and at length have discovered that the purpose is completely and satisfactorily effected by the addition, in a certain part of the process, of a small portion of fresh pancreas."

The fluid meat so prepared is entirely free from any bitter flavor. One ounce is the equivalent of 20 ounces of meat.

Do Planets vary in Color?—In a note to the Royal Astronomical Society, Lieutenant-Colonel Strange, F. R. S., suggests that the changes of color which have been observed at distant intervals in some of the planets, may after all be an affair of the optical instruments through which the light is made to pass, rather than any real alteration in the aspect of the planet itself. That optical instruments do sometimes give the impression of a color different from that belonging to the object from which the light proceeds, appears from the following, which we quote from Colonel Strange's communication:

"I was, within the last few days, at a theatre with two young ladies. They drew my attention to 'the lady opposite in pink.' Turning my glass to her, I replied, 'You mean the lady in yellow.' 'No,' replied both, 'her dress is pink.' Having ascertained that we all spoke of the same person, I begged my companions to use their glasses. On doing so they both at once admitted the color to be yellow, as I had said. But they assured me that to their naked eye it was pink as before. One of the young ladies, my own daughter, is considered to have a remarkably fine eye for color, with the faculty of matching and remembering tints very strongly developed. The other, also a near relative, is likewise an excellent judge of color, and a born artist. The dress about which the above doubt arose was not all colored. It was white, with a great deal of the doubtfully-colored trimming, and the tint (whatever it really may have been) was very pale. There was strong light upon it, and the distance was that of the whole greatest diameter of a small theatre. Such are the facts, on which I do not propose to theorize. But they certainly point at least to one practical consideration—namely, the influence of optical power on color impressions, and the necessity of great caution in pressing observations on the color of heavenly bodies into the service of speculations regarding cosmical changes."

Of the three elements—form, size, color—Colonel Strange believes that color is the least permanently fixed in the "sensorial memory;" so that, even if the light reached the eye of the observer unchanged, the comparison of a recent color-impression with one that was received a long time before must at best give but a doubtful result.

A New Writing-Machine.—The *Mechanics' Magazine* figures and describes a new form of writing-machine, the invention of the Rev. Malling Hansen, superintendent of the Royal Deaf and Dumb Institution of Copenhagen. The machine is designed for rapid writing, and is also capable of being used by the blind. The work is done by means of a series of keys, moved by the fingers something in the same way as the keys of a concertina, each key leaving the impress of its proper letter or character on the paper below when it is struck by the finger. The keys are so disposed that the imprint of each type, when struck, is directed to, and received upon, a central spot, over which the blank paper is made to travel by means of suitable machinery.

Besides offering great facilities for copying purposes, the machine is said to rival stenography as a means for reporting speeches or taking down dictated composition. Rapid writing rarely exceeds four letters per second, while in ordinary speaking from nine to ten, and in rapid speech from fifteen to twenty, letters are uttered per second. This machine, with a little practice, enables the operator to take down an average of twelve letters per second, and an expert manipulator can considerably exceed this. The instrument is in use in London, and its performances are said to be very satisfactory.

Weather-Waste of Coal.—The *Engineer* states that Dr. Varrentrapp has made the weather-waste of coal the subject of an investigation, and as a result asserts that the amount of loss suffered by coal from

exposure to weather is considerable, far greater, indeed, than is generally known. The results of his analyses show in some cases a total loss in weight of a specimen, from this cause, amounting to 33.08 per cent., while its deterioration in quality, for purposes of fuel or gas-making, reached a still higher figure. This change consists in a slow combustion, in which the volatile constituents—which are most valuable combustible elements—are gradually eliminated, while the relative proportions of carbon-ash and sulphur are comparatively augmented. It might be expected, now that the nature of this change is indicated, that anthracite (which has already gone through a very similar process in becoming what it is by the loss of its bituminous matter) should suffer least of all coals from this action, and the result of analysis shows this to be the case. The density and compactness of this variety, aside from its chemical character, protect it in no inconsiderable degree. The cannel coals rank next in their power to resist deterioration from this source, while the bituminous varieties are the most susceptible. The experiments of Dr. Varrentrapp are of such direct and practical importance that all who are engaged in the mining, transportation, storage, or consumption of coal, can study them with profit. It appears from accurate tests of a number of samples before and after exposure, that all the valuable properties of the coal had deteriorated. The coking quality of the weathered coal diminishes with its gas-yielding quality, the author informing us that a sample of coal, yielding when freshly mined a firm, coherent coke, after eleven days' exposure yielded a coke of no coherence, and in all the samples tested the rule was absolute that the longer the coal had been exposed the greater was the inferiority in the quality of the coke it produced. The gas-yielding quality decreased in one instance 45 per cent., and the heating power 47 per cent.; while the same sample under cover lost in the same time but 24 per cent. for gas purposes, and 12 per cent. for fuel. These experiments go far to explain the almost universal inferiority of the slack or waste coals in heating power when prepared for burning, even though some combustible material like pitch or tar is used in their cementation. It indicates, too, the imperative necessity of keeping coals amply protected from the deteriorating action of the air and moisture, by keeping them constantly dry and under cover.

Anecdotes of Rats.—A gentleman, who has passed many years of his life at St. Helena, told me lately several stories about rats, so curious that I thought them worthy of record. He said that at one time the common brown rat was extremely common all over the island, in fact, a perfect pest; and, to avoid its attacks, his father had constructed a large store, rat-proof; i. e., a rat once in could not get out again. A number, however, came in with produce and goods from the ships, and bred there. Around this store were venetian blinds to the windows, and one day one of his men, when it was raining, watched a rat sitting on the venetian, and putting out his tail to collect on it the drippings of water at the edge; he then withdrew it and licked it. The servant told his master, who immediately understood that the rats could get no water inside the store, and therefore directed that a butter firkin should be cut down to four or five inches, and in the top a large circular wire rat-cage trap should be fixed. Several small planks were placed for the rats to get up to the entrance to the cage, which exactly fitted the firkin. No food would have induced the rats to enter the trap, but water did, and many were thus captured. When caught they were given to the dogs; but there was one rat which would not leave the trap for many days. He was well identified day by day, till, becoming incautious, he leaped down, and was immediately killed. There is one peculiarity with these rats, viz., their very often building or making their nests in the trees. I have in India several times found rats'-nests in trees; but then they have always been stolen nests, such as deserted abodes of the squirrel or sparrow; but here my friend, who is no naturalist, tells me that they construct them principally of fir spines, on the ends of the boughs, some twelve or fifteen feet from the ground, in the common fir-trees. The spots selected are just where the overlapping bough nearly meets the lower one. He said that all

know the rats'-nests, and that he had seen them fired at, when many rats were killed, and fell out to the ground. He could tell me no more, and I think that, if original nests, as he held them to be, some grass must be woven in during their construction, as fir-spines have but little power of cohesion. The situation of these nests was worthy of notice, although there is scarcely a situation where a rat's-nest has not been found.—*C. Horne, F. Z. S., in Science Gossip.*

Spontaneous Explosions of Gun-cotton.—Fired in the open air, gun-cotton burns with great rapidity, but does not explode. It has accordingly been the practice to store the manufactured article in more or less open sheds, in boxes containing twenty-five or thirty pounds each. In this condition, however, several explosions have taken place; the most serious being one that occurred at Stowmarket, in England, something less than a year ago. In this case the ignition of the gun-cotton was shown to be due to the presence of a large quantity of sulphuric acid in the stored material; but why it should explode when ignited, instead of burning up in the ordinary way, was not so readily explained. To clear up this point, a set of experiments has lately been carried out, the results of which are given in a recent number of the *Engineer*.

The "service-boxes" in which the gun-cotton is kept are made of inch boards, and, when filled, the cover is tightly screwed on. Twenty-four such boxes were piled in a light wooden hut, similar in construction to the sheds in which gun-cotton is ordinarily stored, and twenty-four others were placed in a close-built brick magazine. Two boxes in each building were left partially open to facilitate ignition of the cotton. The wood hut was ignited by a bonfire of shavings, cotton, and petroleum. It smouldered for about seven and a half minutes, and then broke into the full characteristic gun-cotton flame, when in nine seconds more explosion took place. The cotton in the brick magazine was next ignited; smouldering followed for one minute, fierce gun-cotton flame for ten seconds, then an explosion. Experiments with the wood hut were afterward tried, with the cotton in light wooden boxes, and the lids partially open. It burnt in every experiment without explosion. The results are thus summed up: "Gun-cotton in service-boxes, packed in a close brick magazine, when ignited exploded; gun-cotton in service-boxes tightly screwed down, packed in a wooden hut, exploded; gun-cotton packed in light ½-in. boxes, with lids only partly screwed on and left partly loose, packed in a wood hut, burnt *without* explosion twice. The same experiment, differing only in the cotton being damped, caused *no* explosion." The inference therefore is, that confinement of the gases generated by burning, in tight, strong, wooden boxes, was the cause of the explosions, as, when not so confined, the burning went on as in the open air. "Apparently, the tendency of the experiments is to recommend, as the condition likely to be safest against explosion, that boxes should not be tightly closed or packed in high piles."

Culture of Wild-Plants.—A daughter of Dr. Lockwood, of Freehold, N. J., planted last year in the garden a root of the wild-violet, known to botanists as *Viola sagittata*. It had, during the first ten days of May of this year, borne over *three hundred* flowers, and was at that date a mass of cerulean bloom, with prospect of producing as many hundred more of flowers. The great advantage of this violet is, that its leaves do not grow so high in generous culture as do those of the species *V. cuculata*, or its variety *V. palmata*. Hence the luxuriant mass of flowers is always uppermost, and the rich blue is thus kept conspicuous. This same young lady, at the Monmouth County Fair last year, exhibited a case of living and growing wild-plants under the name "A Cryptogam Garden," which elicited great admiration. It was composed of rare indigenous ferns, all gathered in the wilds of the county. Among these was that graceful rarity, the climbing fern, *Lygodium palmatum*. There were mosses and lichens, and fungi of *recherché* forms and brilliant colors. The effect was very fine, and showed how rich are the resources at hand where there is a little taste to turn them to account.

Chameleonization in Frogs and Reptiles.—We published, in a previous number, a

curious and interesting article by a German oculist, showing how the colors of paintings are affected by changes in the eye of the painter. M. Pouchet matches this discovery with the curious fact that the lower animals change their own colors through the action of the eye. In a recent work on change of color in crustacea, this author shows that in fishes, especially the turbot, notable changes of color take place, due to the quantity of luminous rays which fall upon the eyes of these animals. The eye is the point of departure for a nervous shock which is transmitted to the skin, and which finally results in a change, more or less complete, of the color of the animal. This shock, starting from the eyes, is transmitted by nerves to the skin; so that, if certain of these nerves be severed, the animal will become striped with clearly-defined bands, the shock being intercepted by the severed nerves, and transmitted by the others. If the animal is deprived of sight, it ceases to change color, and preserves the same tint, whether it be placed on a black or on a white ground. In the course of his researches at Concarneau, M. Pouchet confirmed these results in the case of crustacea.

The skin of the frog becomes clearer when the cutaneous nerves are severed. Prof. Goltz, of Halle, shows that primarily the action of the nerves affects the vessels, and that the change in the pigment-cells is a secondary result, and due to a modification of the circulation. In the active state, these cells are star-shaped, or branching; in repose, they are round. Having removed the spinal cord and brain, if then you sever the nerves leading out to one portion of the skin, that portion will become clearer, the pigment-cells then first assuming the condition of repose. Dr. Witlich thinks this change of color is owing to the decay of the color-bearing cellules, and says it would take place equally in shreds of skin separated from the body. Dr. Mendel, of Berlin, has observed one-sided pigmentation frequently in the insane.

Observations on the Hydrogen-Flame.—Besides the phenomena common to ordinary burning, such as luminosity, the disappearance of oxygen, and of the substance burned, the production of water and carbonic acid, or some other of the various oxides, there are also certain other phenomena that differ with different substances, and that, when known, often become an important means of distinguishing these substances. Thus, burning sodium gives a yellow flame; burning potassium, a flame of a purple color; burning arsenic, a strong odor of garlic; burning sulphur, suffocating fumes of sulphurous acid, and so on. Burning hydrogen also has its peculiar phenomena, which have lately been made the subject of further investigation by Mr. W. F. Barrett, who contributes an interesting account of his researches to a recent number of *Nature*.

To study these phenomena to the best advantage, three things, he says, are requisite: 1. That the gas be purified and stored in the ordinary way; 2. That it be led through red or black India-rubber tubing to a platinum, or, better, a steatite jet; 3. That it be burnt in a perfectly dark room, and amid calm and dustless air. In this way, the flame gives a faint, reddish-brown color, invisible in bright daylight. Issuing from a narrow jet in a dark room, a stream of luminosity more than six times the length of the flame is seen to stretch upward from the burning hydrogen. This weird appearance is probably caused by the swifter flow of the particles of gas in the centre of the tube. The central particles, as they shoot upward, are protected awhile by their neighbors; metaphorically, they are hindered from entering the fiery ordeal which dooms them finally to a watery grave.

Brought in contact with certain solid bodies, the flame gives rise to phosphorescent effects. Thus, allowing it to play for a moment on sand-paper, and then promptly extinguishing the gas, a vivid-green phosphorescence remains for some seconds. A similar appearance follows when the flame is directed upon white writing-paper, marble, chalk, granite, or gypsum.

A much more general effect than the one last mentioned is, the production of a magnificent blue image of the flame, that starts up on almost every substance with which the flame is brought into contact. When directed either vertically or sideways, say upon a white plate, or block of marble, there instantly appears a deep-blue and

glowing impression of the exact size and shape of the hollow flame. The moment the gas is extinguished, or the flame removed to the slightest distance from the solid, the effect ceases. This appearance, and the blue tinge which is said to be peculiar to the hydrogen-flame, are really due, according to Mr. Barrett, to the presence of sulphur, and so delicate is the reaction with this substance, that, without the greatest care in purifying the gas, and cleansing the surfaces with which, when burning, it is brought in contact, sufficient sulphur will be present to perceptibly color the flame. The least trace of phosphorus is also made apparent by the hydrogen-flame, by the production of a vivid-green light. When made to play upon the surface of clean tin, or some alloy of tin, a fine scarlet color is almost instantly produced, though the appearance is less vivid than with either sulphur or phosphorus.

Many gases also impart color to the hydrogen-flame; hydrochloric-acid gas giving a reddish-brown flame; ammonia gas a yellow flame, etc. Carbonic-acid gas, even in the smallest proportions, gives the flame a pale lilac tinge, the color being most marked at the base of the flame.

Mr. Barrett suggests that the delicacy of these various reactions makes it possible to turn them to valuable practical account, in the detection of the substances named. When, for example, the air of a room has become vitiated by the accumulation of an undue amount of carbonic acid gas, the hydrogen-flame, by means of suitable apparatus, will readily make the condition known. This practical side of the subject is now engaging Mr. Barrett's attention.

Recent Cave Explorations.—Some highly-important discoveries have lately been made in a cave near Luchon, France, by M. Piette, of the Geological Society. The soil of the cavern consists of several layers—the lowermost ones being characterized by the bones of the reindeer, and by dressed flints like those of the grotto of Laugerie-basse. These layers enclose, in addition to human bones, a large fauna, and particularly a considerable quantity of carved bones and stones. Nowhere else has so great an accumulation of prehistoric works of art been found. The figures often cannot be recognized; still on the bones are seen some designs of considerable finish. M. Piette mentions, among other carvings, some that represent flocks of wild-goats, and herds of reindeer, the head of a rhinoceros, a wolf, horses, a lion's head with mane, etc. These valuable remains are buried in a black soil, filled with ashes. Near the surface of this layer the fauna is the same as it is below, but the carvings are very different from those underneath, and show a very marked decadence. While the lower ones reproduce Nature exactly, with extreme care and a certain minuteness of observation, the upper ones are fantastical and not after Nature, as well as ruder than the others. All the human bones, especially the bones of the skull, are reduced to small fragments, and all have notches and incisions more or less deep. This, M. Piette takes as an evidence of cannibalism. The topmost layer is hard and compact.

Relation of Death-rate to Temperature.—In a little work on the climate of Uckfield (England), Mr. J. Leeson Prince has the following concerning the influence of temperature on the death-rate:

"The mean annual temperature varies 5°.3, viz.: from 51°.93 in 1857, to 46°.62 in 1845, and although at first sight this difference may not appear considerable, yet it is sufficient to exert an enormous influence upon the general character of the seasons, the produce of the soil, and the health of the population. The registrar-general's interesting returns have fully established the important fact that there is a very intimate connection between temperature and mortality. Whenever the mean temperature falls to 45° or thereabouts, the number of deaths from diseases of the respiratory organs increases; and, should it fall below 40°, the death-rate from such diseases is still higher. When a period of intense cold prevails, so that the temperature scarcely rises above the freezing-point for two or three weeks, the number of deaths will be found to exceed what takes place during an epidemic of cholera or scarlet fever. But, when the mean temperature rises to 55°, there will be an increase in the number of deaths from diseases of the abdominal vis-

cera, and this number will fluctuate as the temperature fluctuates between 55° and 65°. Hence we are informed that the mortality from all causes is least when the temperature is about 50°, which is very little above our mean annual temperature."

The Late Eruption.—A correspondent of the London *Athenæum*, writing, May 2d, from Naples, graphically describes the late eruption. He says: A tempest of fine ashes poured down upon us, covering the streets and houses, filling our lungs, and almost blinding us. We all, from necessity, carried umbrellas, a slight protection, however, except to break the brunt of the driving shower as we met it. I have seen cabmen with handkerchiefs hanging in front of their caps, and some men with fine handkerchiefs tied over their faces. Last Friday and Saturday it was, as it were, one continuous roll of artillery, so loud that it could be heard full 20 miles distant; but after the sandstorm set in, if not so sharp and violent, it was, I think, more appalling. Vesuvius roared night and day; it rendered sleep impossible; its reverberations shook our windows and our houses, and great has been the exodus from Naples of the foreigners who came to admire, and now have fled in fright.

It is impossible adequately to describe the beauty and grandeur of the spectacle. In its totality it met the eye—one could watch the swelling growth of the eruption, its every movement, and mark all the exquisite proportions of that wonderful creation, whereas close under the mountain there was a terrific confusion of forms. On the afternoon of Wednesday week there was a grand display, which would have been sufficient for one season, and foreigners might have dispersed to their homes, delighted that they had at last witnessed a brilliant eruption of Vesuvius. On the Thursday it was less active, but in the night there was a cannonade, a loud continuous roar, which never ceased a moment for 48 hours. At the distance of 20 miles it shook the windows and murdered sleep; and one thought only of the havoc which was then being committed on fair lands and populous villages. Like a gigantic cauliflower rose up that vast mass of fire and smoke. Do not smile at the homeliness of the comparison, for it is the only one which really represents its form. Its thousand involutions, round and swelling, are well imaged by the sections of the plant, and as they emerged from the volcano they grew in height and magnitude, and intermingled and rolled one over the other until they ascended to the zenith, and then toppled over, section after section, and fell by their own weight. I could see the showers of dust on either side, and in the midst, burning stones like stars; yet the height of this marvellous form was never lessened, for underneath curled up continually fresh supplies, while the thunder, which rolled fearfully, gave a never-failing impulse to their ascent. A slight wind from the northwest detached portions of the column on one side, and sent them down the coast for miles, in one long cloud; as the wind varied, it was swept inland, or across the sea. And then the colors, how exquisite they were! There were artists with me who positively raved. We had the pure white of the homely plant on the summit, while each section was divided from the other by a shade of black. As the setting sun cast its light upon it, we had all the prismatic colors of the rainbow, and then night fell, and the entire mountain, the heavens above and the sea beneath, were on fire.

Eastern Thibet.—According to Dr. Campbell, from whose papers on Eastern Thibet *Nature* gives an interesting abstract, the *dong* or wild-yak of that country is the fiercest of all known ruminants, rarely allowing a man to escape if it can come up with him. Like the American buffalo, this animal is generally hunted on horseback. The domesticated yak and the sheep are used for the transportation of salt, which is brought from all but inaccessible districts, having an elevation of some 22,000 feet, and where it is so cold that salt can only be obtained from April to November. The sheep carries a load varying in weight from eight to twenty-four pounds, according to the character of the route; the salt is thus conveyed to places accessible by yaks, which are capable of bearing a load of 160 pounds.

There are no leeches or mosquitoes in

Thibet, nor are maggots or fleas ever seen there; and in Dingcham, or Thibet proper, there are no bees or wasps.

Of the mineral productions of the country, a form of carbonate of soda called *pen*, borax, saltpetre, common salt, gold, and arsenic, are spoken of by Dr. Campbell. There are no mines of iron, silver, copper, quicksilver, lead, or coal; the latter substance is, however, imported from China.

The turquoise, real or artificial, is universally worn in rings, necklaces, etc., and large amber-like beads are a favorite ornament, but it is uncertain whether they are natural products of Thibet. The latter are apparently composed of turpentine, mixed with some hardening material. Numerous imitations of turquoise are imported from China; and real but not valuable stones are sent, *via* Cashmere (but from what locality is not stated). The only test of a real stone that is resorted to by the Thibetans is to make a fowl swallow it; if real, it will pass through unchanged.

Dr. Campbell gives some very interesting information regarding the food of the Thibetans. During the summer months they use very little fresh meat. They do not like it boiled, and are not partial to it raw, unless it has been dried. In November there is a great slaughter, and a wealthy man, who has perhaps 7,000 sheep, will kill 200 at this time for his year's consumption. The animal after being killed is skinned and gutted, and then placed on its feet in a free current of air. In a couple of days it becomes quite hard, and is then ready for eating. It is kept in this way for more than a year without spoiling, even during the rainy periods. When long exposed to the wind of Thibet it becomes so dry that it may be rolled into powder between the hands. In this state it is mixed with water and drunk, and used in various other ways. The Thibetans eat animal food in endless forms, and a large portion of the people live on nothing else. The livers of sheep and other animals are similarly dried or frozen, and are much prized, but to strangers they are very distasteful for their bitterness and hardness. The fat is dried, packed in the stomachs, and then sent to market or kept for home use.

With regard to edible vegetables, it is stated that wheat, barley, and buckwheat, sown in April or May, and irrigated, are reaped in September, barley in Thibet taking the place of potatoes in Ireland, four-fifths of the population living on it. Besides these, the other crops are composed of peas, turnips, and a little mustard. The grain is ground in water-mills. The bread is all unleavened, and cooked on heated stoves or gridirons. The sweet, pure farinaceous taste of the fine flour equals the best American produce. The staple food of the country is *champa*, called *suttoo* in India; it is finely-ground flour of toasted barley. It is much eaten without further cooking; mixed up with hot tea it is called *paak*, and when prepared with tepid water it is known as *seu*. If any of our readers wish to enter upon "pastures new" in the breakfast department, they may try *tookpa*, which, to be properly appreciated, should be taken at daybreak before any matutinal ablutions. It is a sort of broth made with mutton, champa, dry curds, butter, salt, and turnips.

Goats are also reared in considerable flocks, but for their milk rather than their flesh. The milk of yaks, cows, sheep, and goats, is used alike for making dried curds and the various preparations of milk used by these people. Mares' milk is not used in Eastern Thibet.

Among the afflictions of the Thibetans Dr. Campbell mentions *groomtook*, or *the laughing disease*, which consists of violent fits of laughter, with excruciating pain in the throat. It equally attacks men and women, and often proves fatal in a few days.

Flying Reptiles of the Chalk Formations in Kansas.—Prof. E. D. Cope, whose industry and genius have done great service in making us familiar with the strange animal forms of the reptilian age in this country, describes two species of flying saurians found by himself in the chalk-deposits of Kansas. One of these had probably been discovered previously by Prof. Marsh, of New Haven, and described under a name different from that given by Prof. Cope.

These belong to a genus which comprises the largest of the pterodactyles or flying saurians, a class of reptiles long since found in Europe, but not until recently discovered in this country.

One of the Kansas species measures 18 feet between the tips of its wings, while the expanded wings of the other would cover an expanse of 25 feet.

These animals had strong, claw-bearing digits, and a short tail, with slender heads, and teeth indicating carnivorous habits.

"We may imagine them," says Prof. Cope, "flapping their leathery wings over the waves, and plunging, often seizing many an unsuspecting fish; or, soaring at a safe distance, viewing the sports and combats of the more powerful saurians of the sea. At nightfall they may have suspended themselves from cliffs by the claw-bearing fingers of their wing-limbs."

Origin of Cholera.—According to a recent paper by Mr. B. G. Jenkins, on the origin and distribution of cholera epidemics, of which *Nature* gives an interesting abstract, the ancients were not so far wrong, after all, in their belief that the heavenly bodies were intimately connected with the origin and course of disease. Instead of one "home" of the cholera in the delta of the Ganges, this writer holds that there are seven, all situated on or near the Tropic of Cancer. These are equally distant from each other, and, while that at the mouth of the Ganges is the most important, the others, which are to the east of China, to the north of Mecca, on the west coast of Africa, to the north of the West India Islands, to the west of Lower California, and among the Sandwich Islands, are well marked, and have all been the starting-point of "cholera-streams" 1,400 miles in breadth, which took either a northwesterly or southwesterly direction, or both. After pointing out the rise and progress of the disease within the limits of these several streams, the author mentions the curious cases of ships at sea being suddenly attacked by cholera; and again, the instances of ships sailing along the coast of India being struck by the disease when at the same place, explaining them on the supposition that the ships had been sailing within the limits of the cholera-streams; for, when they got outside the limits, the disease suddenly ceased. He called attention also to the fact that all the places recorded by Dr. Gavin Milroy as unaffected hitherto by cholera, lie outside these streams, or in their possible, but not actual, extension.

Leaving this part of the subject, he next discusses the origin of the disease, declaring that "cholera is intimately connected with auroral displays and with solar disturbances." Instancing the observed periodicity of the sun-spots, of the diurnal variation in the amount of declination of the magnetic needle, of the earth-currents, and of the auroræ, he traces a curious coincidence in the periodicity of cholera epidemics, expressing the belief that they have a period equal to a period and a half of sun-spots. He adds: "My own opinion, derived from an investigation of the subject, is that each planet, in coming to, and in going from, perihelion—more especially about the time of the equinoxes—produces a violent action upon the sun, and has a violent sympathetic action produced within itself—internally manifested by earthquakes, and externally by auroral displays and volcanic eruptions, such as that of Vesuvius at the present moment; in fact, just such an action as develops the tail of a comet when it is coming to, and going from, perihelion; and, when two or more planets happen to be coming to, or going from, perihelion at the same time, and are in, or nearly in, the same line with the sun—being, of course, nearly in the same plane—the combined violent action produces a maximum of sun-spots, and in connection with it a maximum of cholera on the earth. The number of deaths from cholera in any year—for example, the deaths in Calcutta during the six years 1865–'70—increased as the earth passed from perihelion, especially after March 21st, came to a minimum when it was in aphelion, and increased again when it passed to perihelion, and notably after equinoctial day; thus affording a fair test of my theory."

The Yellowstone National Park.—Interesting details of the Yellowstone National Park reservation are given by F. V. Hayden, United States Geologist, in his fifth annual report on the Geology of the Territories, just published.

By act of Congress, approved March 1, 1872, a tract of land in the Territories of Montana and Wyoming is set apart and reserved for a national park. It is situated

between 44° and 45° of north latitude—nearly the same as are the White Mountains and the Adirondacks—is 65 by 55 miles in area, and comprises 3,575 square miles.

Every portion of this area is more than 6,000 feet above the level of the ocean, or nearly as high as the summit of Mount Washington. In it is a beautiful sheet of water, the Yellowstone Lake, 330 square miles in area, and 7,427 feet above the sea. Tremendous gorges, chasms, cañons, waterfalls, and forest, make this whole tract surpassingly wild. It is walled on every side by mountain-ridges, from 10,000 to 12,000 feet high. On these elevated summits lie perpetual snows, which feed three of the largest rivers in North America.

The sources of the Yellowstone and Missouri, which empty into the Mississippi, and thence into the Gulf of Mexico—of the Snake River, which flows westward to the Columbia and the Pacific—of the Green River, which discharges its waters through the Colorado into the Gulf of California—are among these mountains.

This whole region was in recent time volcanic. The mountains are of volcanic origin. A vast number of hot springs, mud-volcanoes and geysers of a temperature from 100° to 195° Fahrenheit, indicate the close proximity of the unextinguished fires.

On account of its great elevation, frost forms every month in the year. In summer the thermometer falls to 26°, but the air is clear and invigorating. The reservation of this wild and magnificent tract, so abounding in the most wonderful phenomena of Nature, was a wise foresight, and a tribute to Science in the highest degree honorable to our government.

At a recent dinner of the London Academy of Art, Prof. Tyndall thus happily expressed himself touching the relations of art and science: "There is no reason why art and science should not dwell together in amity; for, though they are both suitors of the same mistress, Nature, they are so in a sense and fashion which preclude the thought of jealousy on either side. You love her for her beauty, we for her order and her truth; but I trust that neither of us is so narrow-hearted as to entirely exclude from himself the feelings which belong to the other. Indeed, each is necessary to the completion of the other. The dry light of the intellect, the warm glow of the emotions, the refined exaltation of the æsthetic faculty, are all part and parcel of human nature; and to be complete we must be capable of enjoying them all. Trust me that we, whose light on earth is for the most part that dry light to which I have referred, often seek, and sometimes have, 'glimpses that make us less forlorn' of those aspects of Nature which reveal themselves in all their fulness to the eyes of art. We need such glimpses as a compensation for much that the times have taken away from us. There are some of us workers in science who largely share the poet's yearning to 'hear old Triton blow his wreathèd horn,' and who, nevertheless, in opposition to natural bias, have been compelled to give up, not only Triton, but many later forms of the power which for a time assumed his shape. Emptied of the hopes and pleasures flowing from such conceptions, we stand in more special need of all that Nature has to offer in the way of grandeur and beauty, of all that history has to offer in the way of strength and inspiration, and of such interpretations, by men of genius, of Nature, history, and contemporary life, as at this moment adorn these walls. If I might employ, in a sense so qualified as to render me sincere in using it, a form of language familiar to you all, I would say that we interpret these works of genius, these achievements in which our best men embody their highest efforts, as the outcome of the cultivated, but at the same time inborn and unpurchasable gift of God. For, though the laborer be worthy of his hire, and though the leaders both in arts and science may now by good right make pleasant terms with the world, they reached the position which enables them to do this through periods of labor and resolute self-denial, during which their arts and their science were to them all in all; and reward was the necessary incident and not the motive power of their lives."

Mr. James Geikie, in a fourth paper on "Changes of Climate during the Glacial Epoch," thus states his views as to the sequence of climates in England during this time: First, a succession of alternate gla-

cial and temperate conditions, but associated with the great continental ice-sheets; second, a temperate climate with removal of the ice-sheets from low grounds; third, a period of subsidence, with temperate climate, and much denudation of moraines; fourth, a period of emergence, with arctic conditions, floating ice dispersing erratics, and deposition of clays with arctic mollusca; and, fifth, a period of local glaciers in Britain and Ireland, with gradual amelioration of climate.

DR. COBBOLD says that, when once the trichina has gained admission to our muscles, all hopes of dislodging it are at an end; but, if a person suspects that he has eaten diseased or trichinized meat, he should lose no time in seeking assistance. Immediate advice, followed by suitable remedy, might be the means of saving his life, whereas a few days' delay would perhaps prove fatal. While the worms are in the intestinal canal, we can get rid of them; but, when once the trichinal brood migrates into the flesh, no means are known by which their expulsion can be effected.

A BERLIN lithographer, after years of study, is said to have at last succeeded in producing a paper for printing money which it is impossible to imitate. The color of the paper is the only secret on which the invention rests. The inventor says the colors cannot be chemically analyzed; with the magnifying-glass they can be distinguished from all other colors, and in their quality as colors they cannot be imitated by photography, nor in any other way.

NOTES.

ACCORDING to the observations of a writer in *Land and Water*, the time required for fish-eggs to hatch varies greatly with different seasons. He states that in 1869 ova from the trout hatched in 55 days, in 1870 they were 92 days hatching, in 1871 95 days, and in 1872 they hatched in 82 days. With the exception of temperature, the conditions were identical in the different years. The first year there was no frost, and the ova were in a house with a glass roof, and consequently at a high temperature. The second and third years there were long frosts after the eggs were placed in the boxes, and this year there was also some frost.

CATOPTRIC lamps, or lamps provided with reflectors, are being introduced in London for lighting the streets. The reflectors are so placed in the top of the lamp that those portions of the light ordinarily passing skyward are made to illuminate the foot-ways. The light is evenly distributed; and from the same jet, as shown by the photometer, three times as much illuminating power is obtained as by the old-fashioned lamp.

PROF. PEPPER, of ghostly fame, is giving in London a popular scientific entertainment, followed by a lecture on "spiritualism." The professor announces himself as ready to give all the "manifestations" usual at "spirit *séances*." He "tips" the tables, and "scratches" the same, with all the airy grace of a disembodied sprite. The "hand of glory" is to be seen at his entertainments, and a violin is made to float in the air. Mr. Pepper has not yet perfected his arrangements for "floating" himself *à la Home*, but that feat is "on the bills," and will be performed in a few days. The means by which he performs these marvels he keeps secret at present, but promises to publish them after a few months.

THE use of rubber plates and rings, for making connections between steam and other pipes, is often attended with much annoyance, owing to the leakage of the joints. This may be prevented by employing a cement prepared by dissolving shellac in ammonia. The pulverized gum-shellac is soaked in ten times its weight of strong ammonia, when a slimy mass is obtained, which in three or four weeks will become liquid without the use of hot water. This fastens well both to the rubber and to the metal or wood, and becomes, by volatilization of the ammonia, hard and impermeable to either gases or fluids.

COLORING MATTER IN FUNGI.—Mr. H. C. Sorby has determined the existence of at least 30 distinct coloring substances in fungi. The majority contain at least two, and many of them several, different kinds. Twenty of these have such well-marked optical qualities that they could be recognized without difficulty in other plants, but only one of them, a fine orange-color, is known to exist in any plant not a fungus. As far as Mr. Sorby's observations extend, there is little or no specific agreement between the substances found in fungi and those met with in algæ and lichens, though the two latter orders are closely related in this respect.—*Science Gossip.*

PROF. HERMAN, in a paper published in *Pflüger's Archiv*, states that living muscle offers very much greater resistance to an electric current passing in a direction across

the fibres, than to one transmitted along them, the average difference being as seven to one. In muscles that have passed into the condition of *rigor mortis* (stiffening of death), this difference almost entirely disappears. A similar difference in the amount of resistance offered to the passage of an electric current is observed in the case of the nerves, though the ratio is somewhat less, being about five to one.

NEW FOSSIL FISH.—Sir Philip Egerton has just described a new genus of fossil fish from the lias of Lyme Regis, to which he has given the name *Prognathodus*. Dr. Günther is of opinion that in its dentition it establishes an additional piece of evidence in favor of the connection between the Ganoid and Chimæroid forms.

THE liability of glued articles to come to pieces when exposed to the action of water, especially hot water, is familiar to every one. By adding to the water, with which the glue is mixed when required for use, a small quantity of bichromate of potash, and afterward exposing the part to which it is applied to light, the glue is rendered insoluble, and articles fastened with it resist the action of water. The proportion of bichromate of potash to be taken must be determined by experiment, but for most purposes one-fiftieth of the amount of glue employed will be sufficient.

THE Emperor William, who, during the late war, became noted for his disinterested generosity in ascribing the numerous German successes to the favoring hand of Providence, is now furnishing more substantial, and if possible more high-sounding tokens of his regard, in the shape of church-bells, which the *Builder* tells us are being cast in great numbers from the cannon captured from the French, for use in German churches.

CERTAIN minerals, such as rose-colored silex, native arsenic, and red arsenic, undergo a change when the solar ray falls upon them. The last-named mineral is reduced to a powder, and its red crystals change to orange-color. M. Jannetay, of the French Geological Society, has studied the action of the various luminous rays in this regard, and finds that the red rays alone do not alter the minerals in question.

M. LOUVEL proposes to store grain in air-tight granaries from which the air may be partially exhausted by means of a powerful air-pump. He claims that in this way grain may be much better preserved from decay, and the ravages of insects are effectually stopped. The cost of such a granary capable of holding 300 bushels of wheat would be, in France, about 150 dollars.

THE subcutaneous injection of morphia in cholera has been satisfactorily tried by Dr. Augustus Werry, of Constantinople. In from 15 to 20 minutes after the injection, the patients fell into a calm sleep, and awoke in two or three hours bathed in a warm perspiration, and saying that they were "well again." Dr. Werry treated in this way 22 cases of cholera, presenting almost every phase of the disease, violent vomiting and cramps, dyspnœa, reduced temperature of the body, diarrhœa, weakened circulation, etc., and always with beneficial results. The dose of morphia injected varied from one-twelfth to one-half of a grain.

ACCORDING to a correspondent in *Harper's Weekly*, the horned frog of our Western plains is ovoviviparous, that is, producing eggs that are hatched before leaving the mother's body, the young being brought forth alive. He states that, while crossing the plains some years ago, he carried with him several of these animals, and, on examining them one night, found that 24 young ones had suddenly made their appearance, each one about the size of a dime, and all very lively.

A CERTAIN M. Donac has recently laid before the French Academy of Sciences a project for liquefying dead bodies and transforming them into a syrup without color or smell. According to his calculations, a moderate-sized man could be got into six bottles. The size of each bottle is not stated, but the *Paris Journal* appears charmed with the idea, and exclaims, "What an opening for the exercise of filial piety!"—*Lancet*.

ONE of the ostriches in the Zoological Gardens, London, recently dying, an examination of the stomach showed the cause of death to be copper-poisoning, that organ containing a number of copper coins, and pieces of coins in a much-worn state.

THE death is announced of Professor von Mohl, the eminent botanist, who expired on the 1st of April last, at Tübingen, aged sixty-seven. At thirty years of age he was appointed Professor of Botany and Director of the Botanic Garden, at Tübingen, retaining the position until his death. Since 1843 he has been editor of the *Botanische Zeitung*, and for the last thirty-five years was one of the foreign members of the Linnæan Society. Giving special attention to the study of vegetable anatomy and physiology, he has written extensively on these subjects; his works contain the result of much original observation.

Nature records the occurrence of seven earthquakes in January last. Two were in Central and one in South America, three in India, and one in Asia Minor.

ASA GRAY,

President of the American Association for the Advancement of Science.